THE SEMICONDUCTOR DATA BOOK

MOTOROLA Semiconductor Products Inc.

FOURTH EDITION

SUPPLEMENT 2

LIMA TECHNICAL COLLEGE
OSU LIMA CAMPUS
4240 Campus Drive
LIMA, OHIO 45804

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MICROCIRCUIT COMPONENTS

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The Semiconductor Data Book

SUPPLEMENT 2

This is the second supplement to the 4th Edition of the Semiconductor Data Book originally published in July 1969. It is produced to keep an up-to-date listing of the most advanced semiconductor products.

Devices characterized in this supplement include only the type numbers introduced after the publication of the Semiconductor Data Book and Supplement 1. For a complete compilation of all devices, use Supplement 2 in conjunction with the Data Book and Supplement 1.

The information in this supplement has been carefully checked and is believed to be reliable; however, no responsibility is assumed for inaccuracies.

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ERRATA

The following corrections and changes apply to data sheets in the Semiconductor Data Book, Fourth Edition.

Please make the following changes in the Electrical Characteristics Table (I_R column)

1N3821 thru 1N3830 Zener Diodes

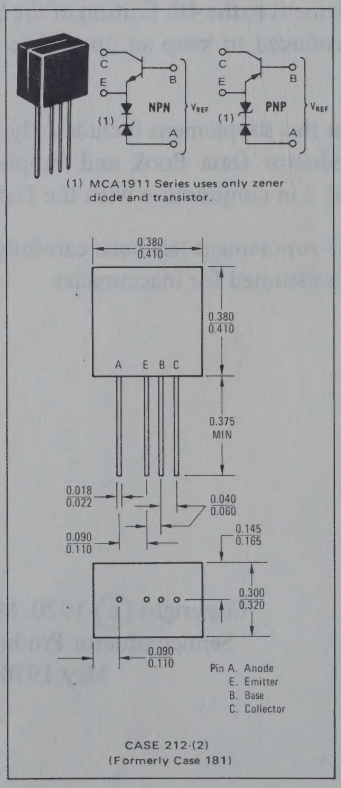
JEDEC Type No.	I_R μA Max @	V_R Volts
1N3821	100	1.0
1N3822	100	1.0
1N3823	50	1.0
1N3824	10	1.0
1N3825	10	1.0
1N3826	10	1.0
1N3827	10	2.0
1N3828	10	3.0
1N3829	10	3.0
1N3830	10	3.0

MCA1911N,P series
6.8 Volts

MCA2011N,P series
8.6 Volts

MCA2111N,P series
9.5 Volts

MCA2211N,P series
11 Volts



Package Change:

Device was packaged in Case 181
New Case 212-(2)

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NUMERICAL INDEX

NUMERICAL INDEX

1N--- TYPE NUMBERS

The following table lists EIA-registered devices introduced since the publication of the Motorola Semiconductor Data Book (4th Edition). Major electrical specifications are provided for your convenience.

KEY

RECTIFIERS

V_R = DC Blocking Voltage
V_F = Average Forward Voltage Drop
I_O = Average Rectifier Forward Current
I_R = Average Reverse Current
I_{surge} = Peak Surge Current

ZENER DIODES

V_Z (min) = Minimum Zener Breakdown Voltage (Volts)
V_Z (max) = Maximum Zener Breakdown Voltage (used only when a corresponding V_Z (min) is specified. Otherwise, this column refers to V_Z (nom)* Nominal Zener Breakdown Voltage.)
Tol = Tolerance, for specified Nominal Breakdown Voltage
P_D = Maximum Power Dissipation. M = milliwatts. W = watts

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom)* V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
Numerical Listing of Registered Type Numbers	S = Silicon G = Germanium SE = Selenium	Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book.	Reference device number indicates specific Data Sheet on which device is characterized.										

SHADING INDICATES SIGNAL DIODES

PRV = Peak Reverse Voltage
V_F @ I_F = Maximum Forward Voltage at Indicated Forward Current — M = milliamp, A = amp
I_R = Reverse Current — M = milliamp, * = microamp N = nanoamp
t_{rr} = Reverse Recovery Time

SHADING INDICATES REFERENCE DIODES

TC = Temperature Coefficient
V_Z = Zener Breakdown Voltage
T (min) } Temperature Range
T (max) } over which indicated temperature coefficient is applicable.

The codes listed below define the listed device and indicates the appropriate specification column heading.

R* — Rectifiers
DR — Diode, Reference
DZ — Diode, Zener
DS — Diode, Signal

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5426	S			DS		1.0	40M	1.0*					
1N5433	S			R*	600		2.0		25				
1N5434	S			R*	600		2.0		60				
1N5435	S			R*	600		12		200				
1N5436 thru 1N5439		Microwave Mixers											
1N5476 thru 1N5477		Varactor Diodes, see Table on Page 7											
1N5477	S			R*	6000		0.6	0.350	80				
1N5478	S			R*	7200		0.6	0.350	80				
1N5479	S			R*	8400		0.6	0.350	80				
1N5480	S			R*	9600		0.6	0.350	80				
1N5481	S			R*	12000		0.6	0.350	80				
1N5482	S			R*	2400		1.0	0.350	80				
1N5483	S			R*	3600		1.0	0.350	80				
1N5484	S			R*	4800		1.0	0.350	80				
1N5485	S			R*	6000		1.0	0.350	80				
1N5518	S		1N5518	DZ							3.3*	20	400M
1N5518A	S		1N5518	DZ							3.3*	10	400M
1N5518B	S		1N5518	DZ							3.3*	5.0	400M
1N5518C	S			DZ							3.3*	2.0	400M
1N5518D	S			DZ							3.3*	1.0	400M
1N5519	S		1N5518	DZ							3.6*	20	400M
1N5519A	S		1N5518	DZ							3.6*	10	400M
1N5519B	S		1N5518	DZ							3.6*	5.0	400M
1N5519C	S			DZ							3.6*	2.0	400M
1N5519D	S			DZ							3.6*	1.0	400M
1N5520	S		1N5518	DZ							3.9*	20	400M
1N5520A	S		1N5518	DZ							3.9*	10	400M
1N5520B	S		1N5518	DZ							3.9*	5.0	400M
1N5520C	S			DZ							3.9*	2.0	400M
1N5520D	S			DZ							3.9*	1.0	400M
1N5521	S		1N5518	DZ							4.3*	20	400M
1N5521A	S		1N5518	DZ							4.3*	10	400M
1N5521B	S		1N5518	DZ							4.3*	5.0	400M
1N5521C	S			DZ							4.3*	2.0	400M
1N5521D	S			DZ							4.3*	1.0	400M
1N5522	S		1N5518	DZ							4.7*	20	400M
1N5522A	S		1N5518	DZ							4.7*	10	400M
1N5522B	S		1N5518	DZ							4.7*	5.0	400M
1N5522C	S			DZ							4.7*	2.0	400M
1N5522D	S			DZ							4.7*	1.0	400M
1N5523	S		1N5518	DZ							5.1*	20	400M
1N5523A	S		1N5518	DZ							5.1*	10	400M
1N5523B	S		1N5518	DZ							5.1*	5.0	400M
1N5523C	S			DZ							5.1*	2.0	400M
1N5523D	S			DZ							5.1*	1.0	400M
1N5524	S		1N5518	DZ							5.6*	20	400M
1N5524A	S		1N5518	DZ							5.6*	10	400M
1N5524B	S		1N5518	DZ							5.6*	5.0	400M
1N5524C	S			DZ							5.6*	2.0	400M
1N5524D	S			DZ							5.6*	1.0	400M
1N5525	S		1N5518	DZ							6.2*	20	400M
1N5525A	S		1N5518	DZ							6.2*	10	400M
1N5525B	S		1N5518	DZ							6.2*	5.0	400M
1N5525C	S			DZ							6.2*	2.0	400M
1N5525D	S			DZ							6.2*	1.0	400M
1N5526	S		1N5518	DZ							6.8*	20	400M
1N5526A	S		1N5518	DZ							6.8*	10	400M
1N5526B	S		1N5518	DZ							6.8*	5.0	400M
1N5526C	S			DZ							6.8*	2.0	400M
1N5526D	S			DZ							6.8*	1.0	400M
1N5527	S		1N5518	DZ							7.5*	20	400M
1N5527A	S		1N5518	DZ							7.5*	10	400M
1N5527B	S		1N5518	DZ							7.5*	5.0	400M
1N5527C	S			DZ							7.5*	2.0	400M
1N5527D	S			DZ							7.5*	1.0	400M
1N5528	S		1N5518	DZ							8.2*	20	400M
1N5528A	S		1N5518	DZ							8.2*	10	400M
1N5528B	S		1N5518	DZ							8.2*	5.0	400M
1N5528C	S			DZ							8.2*	2.0	400M
1N5528D	S			DZ							8.2*	1.0	400M
1N5529	S		1N5518	DZ							9.1*	20	400M
1N5529A	S		1N5518	DZ							9.1*	10	400M
1N5529B	S		1N5518	DZ							9.1*	5.0	400M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5529C	S			DZ							9.1*	2.0	400M
1N5529D	S			DZ							9.1*	1.0	400M
1N5530	S		1N5518	DZ							10*	20	400M
1N5530A	S		1N5518	DZ							10*	10	400M
1N5530B	S		1N5518	DZ							10*	5.0	400M
1N5530C	S			DZ							10*	2.0	400M
1N5530D	S			DZ							10*	1.0	400M
1N5531	S		1N5518	DZ							11*	20	400M
1N5531A	S		1N5518	DZ							11*	10	400M
1N5531B	S		1N5518	DZ							11*	5.0	400M
1N5531C	S			DZ							11*	2.0	400M
1N5531D	S			DZ							11*	1.0	400M
1N5532	S		1N5518	DZ							12*	20	400M
1N5532A	S		1N5518	DZ							12*	10	400M
1N5532B	S		1N5518	DZ							12*	5.0	400M
1N5532C	S			DZ							12*	2.0	400M
1N5532D	S			DZ							12*	1.0	400M
1N5533	S		1N5518	DZ							13*	20	400M
1N5533A	S		1N5518	DZ							13*	10	400M
1N5533B	S		1N5518	DZ							13*	5.0	400M
1N5533C	S			DZ							13*	2.0	400M
1N5533D	S			DZ							13*	1.0	400M
1N5534	S		1N5518	DZ							14*	20	400M
1N5534A	S		1N5518	DZ							14*	10	400M
1N5534B	S		1N5518	DZ							14*	5.0	400M
1N5534C	S			DZ							14*	2.0	400M
1N5534D	S			DZ							14*	1.0	400M
1N5535	S		1N5518	DZ							15*	20	400M
1N5535A	S		1N5518	DZ							15*	10	400M
1N5535B	S		1N5518	DZ							15*	5.0	400M
1N5535C	S			DZ							15*	2.0	400M
1N5535D	S			DZ							15*	1.0	400M
1N5536	S		1N5518	DZ							16*	20	400M
1N5536A	S		1N5518	DZ							16*	10	400M
1N5536B	S		1N5518	DZ							16*	5.0	400M
1N5536C	S			DZ							16*	2.0	400M
1N5536D	S			DZ							16*	1.0	400M
1N5537	S		1N5518	DZ							17*	20	400M
1N5537A	S		1N5518	DZ							17*	10	400M
1N5537B	S		1N5518	DZ							17*	5.0	400M
1N5537C	S			DZ							17*	2.0	400M
1N5537D	S			DZ							17*	1.0	400M
1N5538	S		1N5518	DZ							18*	20	400M
1N5538A	S		1N5518	DZ							18*	10	400M
1N5538B	S		1N5518	DZ							18*	5.0	400M
1N5538C	S			DZ							18*	2.0	400M
1N5538D	S			DZ							18*	1.0	400M
1N5539	S		1N5518	DZ							19*	20	400M
1N5539A	S		1N5518	DZ							19*	10	400M
1N5539B	S		1N5518	DZ							19*	5.0	400M
1N5539C	S			DZ							19*	2.0	400M
1N5539D	S			DZ							19*	1.0	400M
1N5540	S		1N5518	DZ							20*	20	400M
1N5540A	S		1N5518	DZ							20*	10	400M
1N5540B	S		1N5518	DZ							20*	5.0	400M
1N5540C	S			DZ							20*	2.0	400M
1N5540D	S			DZ							20*	1.0	400M
1N5541	S		1N5518	DZ							22*	20	400M
1N5541A	S		1N5518	DZ							22*	10	400M
1N5541B	S		1N5518	DZ							22*	5.0	400M
1N5541C	S			DZ							22*	2.0	400M
1N5541D	S			DZ							22*	1.0	400M
1N5542	S		1N5518	DZ							24*	20	400M
1N5542A	S		1N5518	DZ							24*	10	400M
1N5542B	S		1N5518	DZ							24*	5.0	400M
1N5542C	S			DZ							24*	2.0	400M
1N5542D	S			DZ							24*	1.0	400M
1N5543	S		1N5518	DZ							25*	20	400M
1N5543A	S		1N5518	DZ							25*	10	400M
1N5543B	S		1N5518	DZ							25*	5.0	400M
1N5543C	S			DZ							25*	2.0	400M
1N5543D	S			DZ							25*	1.0	400M
1N5544	S		1N5518	DZ							28*	20	400M
1N5544A	S		1N5518	DZ							28*	10	400M
1N5544B	S		1N5518	DZ							28*	5.0	400M

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (Amps)		I_R	t_{rr} (μs)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5544C	S			DZ							28*	2.0	400M
1N5544D	S			DZ							28*	1.0	400M
1N5545	S		1N5518	DZ							30*	20	400M
1N5545A	S		1N5518	DZ							30*	10	400M
1N5545B	S		1N5518	DZ							30*	5.0	400M
1N5545C	S			DZ							30*	2.0	400M
1N5545D	S			DZ							30*	1.0	400M
1N5546	S		1N5518	DZ							33*	20	400M
1N5546A	S		1N5518	DZ							33*	10	400M
1N5546B	S		1N5518	DZ							33*	5.0	400M
1N5546C	S			DZ							33*	2.0	400M
1N5546D	S			DZ							33*	1.0	400M
1N5550	S			R*	200	1.0	3.0	0.025	150				
1N5551	S			R*	400	1.0	3.0	0.025	150				
1N5552	S			R*	600	1.0	3.0	0.025	150				
1N5553	S			R*	800	1.1	3.0	0.025	150				
1N5554	S			R*	1000	1.1	3.0	0.025	150				
1N5555 thru 1N5558	Transient Suppressors, see Table on Page 11												
1N5559	S			DZ							6.8*	20	1.0W
1N5559A	S			DZ							6.8*	10	1.0W
1N5559B	S			DZ							6.8*	5.0	1.0W
1N5560	S			DZ							7.5*	20	1.0W
1N5560A	S			DZ							7.5*	10	1.0W
1N5560B	S			DZ							7.5*	5.0	1.0W
1N5561	S			DZ							8.2*	20	1.0W
1N5561A	S			DZ							8.2*	10	1.0W
1N5561B	S			DZ							8.2*	5.0	1.0W
1N5562	S			DZ							9.1*	20	1.0W
1N5562A	S			DZ							9.1*	10	1.0W
1N5562B	S			DZ							9.1*	5.0	1.0W
1N5563	S			DZ							10*	20	1.0W
1N5563A	S			DZ							10*	10	1.0W
1N5563B	S			DZ							10*	5.0	1.0W
1N5564	S			DZ							11*	20	1.0W
1N5564A	S			DZ							11*	10	1.0W
1N5564B	S			DZ							11*	5.0	1.0W
1N5565	S			DZ							12*	20	1.0W
1N5565A	S			DZ							12*	10	1.0W
1N5565B	S			DZ							12*	5.0	1.0W
1N5566	S			DZ							13*	20	1.0W
1N5566A	S			DZ							13*	10	1.0W
1N5566B	S			DZ							13*	5.0	1.0W
1N5567	S			DZ							15*	20	1.0W
1N5567A	S			DZ							15*	10	1.0W
1N5567B	S			DZ							15*	5.0	1.0W
1N5568	S			DZ							16*	20	1.0W
1N5568A	S			DZ							16*	10	1.0W
1N5568B	S			DZ							16*	5.0	1.0W
1N5569	S			DZ							18*	20	1.0W
1N5569A	S			DZ							18*	10	1.0W
1N5569B	S			DZ							18*	5.0	1.0W
1N5570	S			DZ							20*	20	1.0W
1N5570A	S			DZ							20*	10	1.0W
1N5570B	S			DZ							20*	5.0	1.0W
1N5571	S			DZ							22*	20	1.0W
1N5571A	S			DZ							22*	10	1.0W
1N5571B	S			DZ							22*	5.0	1.0W
1N5572	S			DZ							24*	20	1.0W
1N5572A	S			DZ							24*	10	1.0W
1N5572B	S			DZ							24*	5.0	1.0W
1N5573	S			DZ							27*	20	1.0W
1N5573A	S			DZ							27*	10	1.0W
1N5573B	S			DZ							27*	5.0	1.0W
1N5574	S			DZ							30*	20	1.0W
1N5574A	S			DZ							30*	10	1.0W
1N5574B	S			DZ							30*	5.0	1.0W
1N5575	S			DZ							33*	20	1.0W
1N5575A	S			DZ							33*	10	1.0W
1N5575B	S			DZ							33*	5.0	1.0W
1N5576	S			DZ							36*	20	1.0W
1N5576A	S			DZ							36*	10	1.0W
1N5576B	S			DZ							36*	5.0	1.0W
1N5577	S			DZ							39*	20	1.0W
1N5577A	S			DZ							39*	10	1.0W
1N5577B	S			DZ							39*	5.0	1.0W
1N5578	S			DZ							43*	20	1.0W

TYPE	MATERIAL	REPLACEMENT	REF.	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amp)	I_R (mA)	I_{surge} (Amp)	V_Z (min)	V_Z (nom) * / V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T (min) °C	T (max) °C
1N5578A	S			DZ							43*	10	1.0W
1N5578B	S			DZ							43*	5.0	1.0W
1N5579	S			DZ							47*	20	1.0W
1N5579A	S			DZ							47*	10	1.0W
1N5579B	S			DZ							47*	5.0	1.0W
1N5580	S			DZ							51*	20	1.0W
1N5580A	S			DZ							51*	10	1.0W
1N5580B	S			DZ							51*	5.0	1.0W
1N5581	S			DZ							56*	20	1.0W
1N5581A	S			DZ							56*	10	1.0W
1N5581B	S			DZ							56*	5.0	1.0W
1N5582	S			DZ							62*	20	1.0W
1N5582A	S			DZ							62*	10	1.0W
1N5582B	S			DZ							62*	5.0	1.0W
1N5583	S			DZ							68*	20	1.0W
1N5583A	S			DZ							68*	10	1.0W
1N5583B	S			DZ							68*	5.0	1.0W
1N5584	S			DZ							75*	20	1.0W
1N5584A	S			DZ							75*	10	1.0W
1N5584B	S			DZ							75*	5.0	1.0W
1N5585	S			DZ							82*	20	1.0W
1N5585A	S			DZ							82*	10	1.0W
1N5585B	S			DZ							82*	5.0	1.0W
1N5586	S			DZ							91*	20	1.0W
1N5586A	S			DZ							91*	10	1.0W
1N5586B	S			DZ							91*	5.0	1.0W
1N5587	S			DZ							100*	20	1.0W
1N5587A	S			DZ							100*	10	1.0W
1N5587B	S			DZ							100*	5.0	1.0W
1N5588	S			DZ							110*	20	1.0W
1N5588A	S			DZ							110*	10	1.0W
1N5588B	S			DZ							110*	5.0	1.0W
1N5589	S			DZ							120*	20	1.0W
1N5589A	S			DZ							120*	10	1.0W
1N5589B	S			DZ							120*	5.0	1.0W
1N5590	S			DZ							130*	20	1.0W
1N5590A	S			DZ							130*	10	1.0W
1N5590B	S			DZ							130*	5.0	1.0W
1N5591	S			DZ							150*	20	1.0W
1N5591A	S			DZ							150*	10	1.0W
1N5591B	S			DZ							150*	5.0	1.0W
1N5592	S			DZ							160*	20	1.0W
1N5592A	S			DZ							160*	10	1.0W
1N5592B	S			DZ							160*	5.0	1.0W
1N5593	S			DZ							180*	20	1.0W
1N5593A	S			DZ							180*	10	1.0W
1N5593B	S			DZ							180*	5.0	1.0W
1N5594	S			DZ							200*	20	1.0W
1N5594A	S			DZ							200*	10	1.0W
1N5594B	S			DZ							200*	5.0	1.0W
1N5605	S			DS	70	1.0	20M	25N					
1N5606	S			DS	150	1.0	7.0M	25N					
1N5607	S			DS	200	1.0	3.0M	25N					
1N5608	S			DS	120	1.0	100M	50N					
1N5609	S			DS	120	1.0	6.0M	5.0*					
1N5624	S			R*	200	0.95	3.0	0.3	125				
1N5625	S			R*	400	0.95	3.0	0.3	125				
1N5626	S			R*	600	0.95	3.0	0.3	125				
1N5627	S			R*	800	0.95	3.0	0.3	125				
1N5629,A thru 1N5665,A	Transient Suppressors, see Table on Page 11												
1N5679	S			R*	50	1.1	1.0	0.01	50				
1N5680	S			R*	100	1.1	1.0	0.01	50				

VARACTOR DIODES

INDEX AND SHORT-FORM SPECIFICATIONS

The following table provides a numerical index and short-form specifications for varactor diodes with EIA-registered type number introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY

TYPE	REF.	CAPACITANCE					BV_R	Q @ f	P_D @ 25°C
		C_J C_T* pF	C Tol %	C (max) / C (min)	Voltage Range V_1 Volts	Voltage Range V_2 Volts	Volts	GHz	Watts
Numerical Listing of Registered Type Numbers									
	Reference device number indicates specific Data Sheet on which device is characterized								
		Nominal Capacitance usually C_J (junction capacitance) With *, specified value is C_T (total capacitance) $C_T = C_J + C_C$							
			Tolerance of capacitance listed in preceding column						
				Effective tuning Ratio (Capacitance at Voltage V_1 divided by capacitance at Voltage V_2)					
					Voltage range over which the tuning range is measured				
							Reverse Breakdown Voltage		
								Figure of Merit at this specified frequency	
									Power Dissipation at 25°C

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T*	C Tol	C (max) / C (min)	Voltage Range V_1	Voltage Range V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N5439		3.3*	20	2.3	2.0	30	30	450	0.05	0.4
1N5439A		3.3*	10	2.3	2.0	30	30	450	0.05	0.4
1N5439B		3.3*	5.0	2.3	2.0	30	30	450	0.05	0.4
1N5439C		3.3*	2.0	2.3	2.0	30	30	450	0.05	0.4
1N5439D		3.3*	1.0	2.3	2.0	30	30	450	0.05	0.4
1N5440		4.7*	20	2.4	2.0	30	30	450	0.05	0.4
1N5440A		4.7*	10	2.4	2.0	30	30	450	0.05	0.4
1N5440B		4.7*	5.0	2.4	2.0	30	30	450	0.05	0.4
1N5440C		4.7*	2.0	2.4	2.0	30	30	450	0.05	0.4
1N5440D		4.7*	1.0	2.4	2.0	30	30	450	0.05	0.4
1N5441		6.8*	20	2.5	2.0	30	30	450	0.05	0.4
1N5441A	1N5441A	6.8*	10	2.5	2.0	30	30	450	0.05	0.4
1N5441B	1N5441A	6.8*	5.0	2.5	2.0	30	30	450	0.05	0.4
1N5441C	1N5441A	6.8*	2.0	2.5	2.0	30	30	450	0.05	0.4
1N5441D	1N5441A	6.8*	1.0	2.5	2.0	30	30	450	0.05	0.4
1N5442		8.2*	20	2.5	2.0	30	30	450	0.05	0.4
1N5442A	1N5441A	8.2*	10	2.5	2.0	30	30	450	0.05	0.4
1N5442B	1N5441A	8.2*	5.0	2.5	2.0	30	30	450	0.05	0.4
1N5442C	1N5441A	8.2*	2.0	2.5	2.0	30	30	450	0.05	0.4
1N5442D	1N5441A	8.2*	1.0	2.5	2.0	30	30	450	0.05	0.4
1N5443		10*	20	2.6	2.0	30	30	400	0.05	0.4
1N5443A	1N5441A	10*	10	2.6	2.0	30	30	400	0.05	0.4
1N5443B	1N5441A	10*	5.0	2.6	2.0	30	30	400	0.05	0.4
1N5443C	1N5441A	10*	2.0	2.6	2.0	30	30	400	0.05	0.4
1N5443D	1N5441A	10*	1.0	2.6	2.0	30	30	400	0.05	0.4
1N5444		12*	20	2.6	2.0	30	30	400	0.05	0.4
1N5444A	1N5441A	12*	10	2.6	2.0	30	30	400	0.05	0.4
1N5444B	1N5441A	12*	5.0	2.6	2.0	30	30	400	0.05	0.4
1N5444C	1N5441A	12*	2.0	2.6	2.0	30	30	400	0.05	0.4
1N5444D	1N5441A	12*	1.0	2.6	2.0	30	30	400	0.05	0.4
1N5445		15*	20	2.6	2.0	30	30	400	0.05	0.4
1N5445A	1N5441A	15*	10	2.6	2.0	30	30	400	0.05	0.4
1N5445B	1N5441A	15*	5.0	2.6	2.0	30	30	400	0.05	0.4
1N5445C	1N5441A	15*	2.0	2.6	2.0	30	30	400	0.05	0.4
1N5445D	1N5441A	15*	1.0	2.6	2.0	30	30	400	0.05	0.4
1N5446		18*	20	2.6	2.0	30	30	350	0.05	0.4
1N5446A	1N5441A	18*	10	2.6	2.0	30	30	350	0.05	0.4
1N5446B	1N5441A	18*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5446C	1N5441A	18*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5446D	1N5441A	18*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5447		20*	20	2.6	2.0	30	30	350	0.05	0.4
1N5447A	1N5441A	20*	10	2.6	2.0	30	30	350	0.05	0.4
1N5447B	1N5441A	20*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5447C	1N5441A	20*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5447D	1N5441A	20*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5448		22*	20	2.6	2.0	30	30	350	0.05	0.4
1N5448A	1N5441A	22*	10	2.6	2.0	30	30	350	0.05	0.4
1N5448B	1N5441A	22*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5448C	1N5441A	22*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5448D	1N5441A	22*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5449		27*	20	2.6	2.0	30	30	350	0.05	0.4
1N5449A	1N5441A	27*	10	2.6	2.0	30	30	350	0.05	0.4
1N5449B	1N5441A	27*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5449C	1N5441A	27*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5449D	1N5441A	27*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5450		33*	20	2.6	2.0	30	30	350	0.05	0.4
1N5450A	1N5441A	33*	10	2.6	2.0	30	30	350	0.05	0.4
1N5450B	1N5441A	33*	5.0	2.6	2.0	30	30	350	0.05	0.4
1N5450C	1N5441A	33*	2.0	2.6	2.0	30	30	350	0.05	0.4
1N5450D	1N5441A	33*	1.0	2.6	2.0	30	30	350	0.05	0.4
1N5451		39*	20	2.6	2.0	30	30	300	0.05	0.4
1N5451A	1N5441A	39*	10	2.6	2.0	30	30	300	0.05	0.4
1N5451B	1N5441A	39*	5.0	2.6	2.0	30	30	300	0.05	0.4
1N5451C	1N5441A	39*	2.0	2.6	2.0	30	30	300	0.05	0.4
1N5451D	1N5441A	39*	1.0	2.6	2.0	30	30	300	0.05	0.4
1N5452		47*	20	2.6	2.0	30	30	250	0.05	0.4
1N5452A	1N5441A	47*	10	2.6	2.0	30	30	250	0.05	0.4
1N5452B	1N5441A	47*	5.0	2.6	2.0	30	30	250	0.05	0.4
1N5452C	1N5441A	47*	2.0	2.6	2.0	30	30	250	0.05	0.4
1N5452D	1N5441A	47*	1.0	2.6	2.0	30	30	250	0.05	0.4

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J / C_T*	C Tol	C (max) / C (min)	Voltage Range					
					V_1	V_2				
		pF	%		Volts	Volts	Volts		GHz	Watts
1N5453		56*	20	2.6	2.0	30	30	200	0.05	0.4
1N5453A	1N5441A	56*	10	2.6	2.0	30	30	200	0.05	0.4
1N5453B	1N5441A	56*	5.0	2.6	2.0	30	30	200	0.05	0.4
1N5453C	1N5441A	56*	2.0	2.6	2.0	30	30	200	0.05	0.4
1N5453D	1N5441A	56*	1.0	2.6	2.0	30	30	200	0.05	0.4
1N5454		68*	20	2.7	2.0	30	30	175	0.05	0.4
1N5454A	1N5441A	68*	10	2.7	2.0	30	30	175	0.05	0.4
1N5454B	1N5441A	68*	5.0	2.7	2.0	30	30	175	0.05	0.4
1N5454C	1N5441A	68*	2.0	2.7	2.0	30	30	175	0.05	0.4
1N5454D	1N5441A	68*	1.0	2.7	2.0	30	30	175	0.05	0.4
1N5455		82*	20	2.7	2.0	30	30	175	0.05	0.4
1N5455A	1N5441A	82*	10	2.7	2.0	30	30	175	0.05	0.4
1N5455B	1N5441A	82*	5.0	2.7	2.0	30	30	175	0.05	0.4
1N5455C	1N5441A	82*	2.0	2.7	2.0	30	30	175	0.05	0.4
1N5455D	1N5441A	82*	1.0	2.7	2.0	30	30	175	0.05	0.4
1N5456		100*	20	2.7	2.0	30	30	175	0.05	0.4
1N5456A	1N5441A	100*	10	2.7	2.0	30	30	175	0.05	0.4
1N5456B	1N5441A	100*	5.0	2.7	2.0	30	30	175	0.05	0.4
1N5456C	1N5441A	100*	2.0	2.7	2.0	30	30	175	0.05	0.4
1N5456D	1N5441A	100*	1.0	2.7	2.0	30	30	175	0.05	0.4
1N5457		120*	20	2.7	2.0	30	30	150	0.05	0.4
1N5457A		120*	10	2.7	2.0	30	30	150	0.05	0.4
1N5457B		120*	5.0	2.7	2.0	30	30	150	0.05	0.4
1N5457C		120*	2.0	2.7	2.0	30	30	150	0.05	0.4
1N5457D		120*	1.0	2.7	2.0	30	30	150	0.05	0.4
1N5458		3.9*	20	2.5	2.0	30	30	600	0.05	0.4
1N5458A		3.9*	10	2.5	2.0	30	30	600	0.05	0.4
1N5458B		3.9*	5.0	2.5	2.0	30	30	600	0.05	0.4
1N5458C		3.9*	2.0	2.5	2.0	30	30	600	0.05	0.4
1N5458D		3.9*	1.0	2.5	2.0	30	30	600	0.05	0.4
1N5459		4.7*	20	2.6	2.0	30	30	600	0.05	0.4
1N5459A		4.7*	10	2.6	2.0	30	30	600	0.05	0.4
1N5459B		4.7*	5.0	2.6	2.0	30	30	600	0.05	0.4
1N5459C		4.7*	2.0	2.6	2.0	30	30	600	0.05	0.4
1N5459D		4.7*	1.0	2.6	2.0	30	30	600	0.05	0.4
1N5460		5.6*	20	2.6	2.0	30	30	600	0.05	0.4
1N5460A		5.6*	10	2.6	2.0	30	30	600	0.05	0.4
1N5460B		5.6*	5.0	2.6	2.0	30	30	600	0.05	0.4
1N5460C		5.6*	2.0	2.6	2.0	30	30	600	0.05	0.4
1N5460D		5.6*	1.0	2.6	2.0	30	30	600	0.05	0.4
1N5461		6.8*	20	2.7	2.0	30	30	600	0.05	0.4
1N5461A	1N5461A	6.8*	10	2.7	2.0	30	30	600	0.05	0.4
1N5461B	1N5461A	6.8*	5.0	2.7	2.0	30	30	600	0.05	0.4
1N5461C	1N5461A	6.8*	2.0	2.7	2.0	30	30	600	0.05	0.4
1N5461D	1N5461A	6.8*	1.0	2.7	2.0	30	30	600	0.05	0.4
1N5462		8.2*	20	2.8	2.0	30	30	600	0.05	0.4
1N5462A	1N5461A	8.2*	10	2.8	2.0	30	30	600	0.05	0.4
1N5462B	1N5461A	8.2*	5.0	2.8	2.0	30	30	600	0.05	0.4
1N5462C	1N5461A	8.2*	2.0	2.8	2.0	30	30	600	0.05	0.4
1N5462D	1N5461A	8.2*	1.0	2.8	2.0	30	30	600	0.05	0.4
1N5463		10*	20	2.8	2.0	30	30	550	0.05	0.4
1N5463A	1N5461A	10*	10	2.8	2.0	30	30	550	0.05	0.4
1N5463B	1N5461A	10*	5.0	2.8	2.0	30	30	550	0.05	0.4
1N5463C	1N5461A	10*	2.0	2.8	2.0	30	30	550	0.05	0.4
1N5463D	1N5461A	10*	1.0	2.8	2.0	30	30	550	0.05	0.4
1N5464		12*	20	2.8	2.0	30	30	550	0.05	0.4
1N5464A	1N5461A	12*	10	2.8	2.0	30	30	550	0.05	0.4
1N5464B	1N5461A	12*	5.0	2.8	2.0	30	30	550	0.05	0.4
1N5464C	1N5461A	12*	2.0	2.8	2.0	30	30	550	0.05	0.4
1N5464D	1N5461A	12*	1.0	2.8	2.0	30	30	550	0.05	0.4
1N5465		15*	20	2.8	2.0	30	30	550	0.05	0.4
1N5465A	1N5461A	15*	10	2.8	2.0	30	30	550	0.05	0.4
1N5465B	1N5461A	15*	5.0	2.8	2.0	30	30	550	0.05	0.4
1N5465C	1N5461A	15*	2.0	2.8	2.0	30	30	550	0.05	0.4
1N5465D	1N5461A	15*	1.0	2.8	2.0	30	30	550	0.05	0.4
1N5466		18*	20	2.9	2.0	30	30	500	0.05	0.4
1N5466A	1N5461A	18*	10	2.9	2.0	30	30	500	0.05	0.4
1N5466B	1N5461A	18*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5466C	1N5461A	18*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5466D	1N5461A	18*	1.0	2.9	2.0	30	30	500	0.05	0.4

TYPE	REF.	CAPACITANCE					BV_R	Q @ f		P_D @ 25°C
		C_J C_T* pF	C Tol %	C (max) / C (min)	Voltage Range V_1 Volts	Voltage Range V_2 Volts	Volts		GHz	Watts
1N5467		20*	20	2.9	2.0	30	30	500	0.05	0.4
1N5467A	1N5461A	20*	10	2.9	2.0	30	30	500	0.05	0.4
1N5467B	1N5461A	20*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5467C	1N5461A	20*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5467D	1N5461A	20*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5468		22*	20	2.9	2.0	30	30	500	0.05	0.4
1N5468A	1N5461A	22*	10	2.9	2.0	30	30	500	0.05	0.4
1N5468B	1N5461A	22*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5468C	1N5461A	22*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5468D	1N5461A	22*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5469		27*	20	2.9	2.0	30	30	500	0.05	0.4
1N5469A	1N5461A	27*	10	2.9	2.0	30	30	500	0.05	0.4
1N5469B	1N5461A	27*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5469C	1N5461A	27*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5469D	1N5461A	27*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5470		33*	20	2.9	2.0	30	30	500	0.05	0.4
1N5470A	1N5461A	33*	10	2.9	2.0	30	30	500	0.05	0.4
1N5470B	1N5461A	33*	5.0	2.9	2.0	30	30	500	0.05	0.4
1N5470C	1N5461A	33*	2.0	2.9	2.0	30	30	500	0.05	0.4
1N5470D	1N5461A	33*	1.0	2.9	2.0	30	30	500	0.05	0.4
1N5471		39*	20	2.9	2.0	30	30	450	0.05	0.4
1N5471A	1N5461A	39*	10	2.9	2.0	30	30	450	0.05	0.4
1N5471B	1N5461A	39*	5.0	2.9	2.0	30	30	450	0.05	0.4
1N5471C	1N5461A	39*	2.0	2.9	2.0	30	30	450	0.05	0.4
1N5471D	1N5461A	39*	1.0	2.9	2.0	30	30	450	0.05	0.4
1N5472		47*	20	2.9	2.0	30	30	400	0.05	0.4
1N5472A	1N5461A	47*	10	2.9	2.0	30	30	400	0.05	0.4
1N5472B	1N5461A	47*	5.0	2.9	2.0	30	30	400	0.05	0.4
1N5472C	1N5461A	47*	2.0	2.9	2.0	30	30	400	0.05	0.4
1N5472D	1N5461A	47*	1.0	2.9	2.0	30	30	400	0.05	0.4
1N5473		56*	20	2.9	2.0	30	30	300	0.05	0.4
1N5473A	1N5461A	56*	10	2.9	2.0	30	30	300	0.05	0.4
1N5473B	1N5461A	56*	5.0	2.9	2.0	30	30	300	0.05	0.4
1N5473C	1N5461A	56*	2.0	2.9	2.0	30	30	300	0.05	0.4
1N5473D	1N5461A	56*	1.0	2.9	2.0	30	30	300	0.05	0.4
1N5474		68*	20	2.9	2.0	30	30	250	0.05	0.4
1N5474A	1N5461A	68*	10	2.9	2.0	30	30	250	0.05	0.4
1N5474B	1N5461A	68*	5.0	2.9	2.0	30	30	250	0.05	0.4
1N5474C	1N5461A	68*	2.0	2.9	2.0	30	30	250	0.05	0.4
1N5474D	1N5461A	68*	1.0	2.9	2.0	30	30	250	0.05	0.4
1N5475		82*	20	2.9	2.0	30	30	225	0.05	0.4
1N5475A	1N5461A	82*	10	2.9	2.0	30	30	225	0.05	0.4
1N5475B	1N5461A	82*	5.0	2.9	2.0	30	30	225	0.05	0.4
1N5475C	1N5461A	82*	2.0	2.9	2.0	30	30	225	0.05	0.4
1N5475D	1N5461A	82*	1.0	2.9	2.0	30	30	225	0.05	0.4
1N5476		100*	20	2.9	2.0	30	30	200	0.05	0.4
1N5476A	1N5461A	100*	10	2.9	2.0	30	30	200	0.05	0.4
1N5476B	1N5461A	100*	5.0	2.9	2.0	30	30	200	0.05	0.4
1N5476C	1N5461A	100*	2.0	2.9	2.0	30	30	200	0.05	0.4
1N5476D	1N5461A	100*	1.0	2.9	2.0	30	30	200	0.05	0.4

TRANSIENT SUPPRESSOR DIODES

INDEX AND SHORT FORM SPECIFICATIONS

The following table provides a numerical index and short-form specifications for Voltage Transient Suppressor diodes with EIA-registered type numbers introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY

TYPE	REPLACEMENT	REFERENCE	$V_{(BR)R}$	I_R	V_{RM}	V_R	i_R	TC
Numerical Listing of Registered Type Numbers.								
	Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book							
		Reference device number indicates specific Data Sheet on which device is characterized						
			Breakdown Voltage					
				Reverse Current				
					Reverse Voltage (working) @ $T_A = 25°C$			
						Peak Reverse Voltage during Reverse Surge		
							Maximum Surge Current	
								Temperature Coefficient of Breakdown Voltage

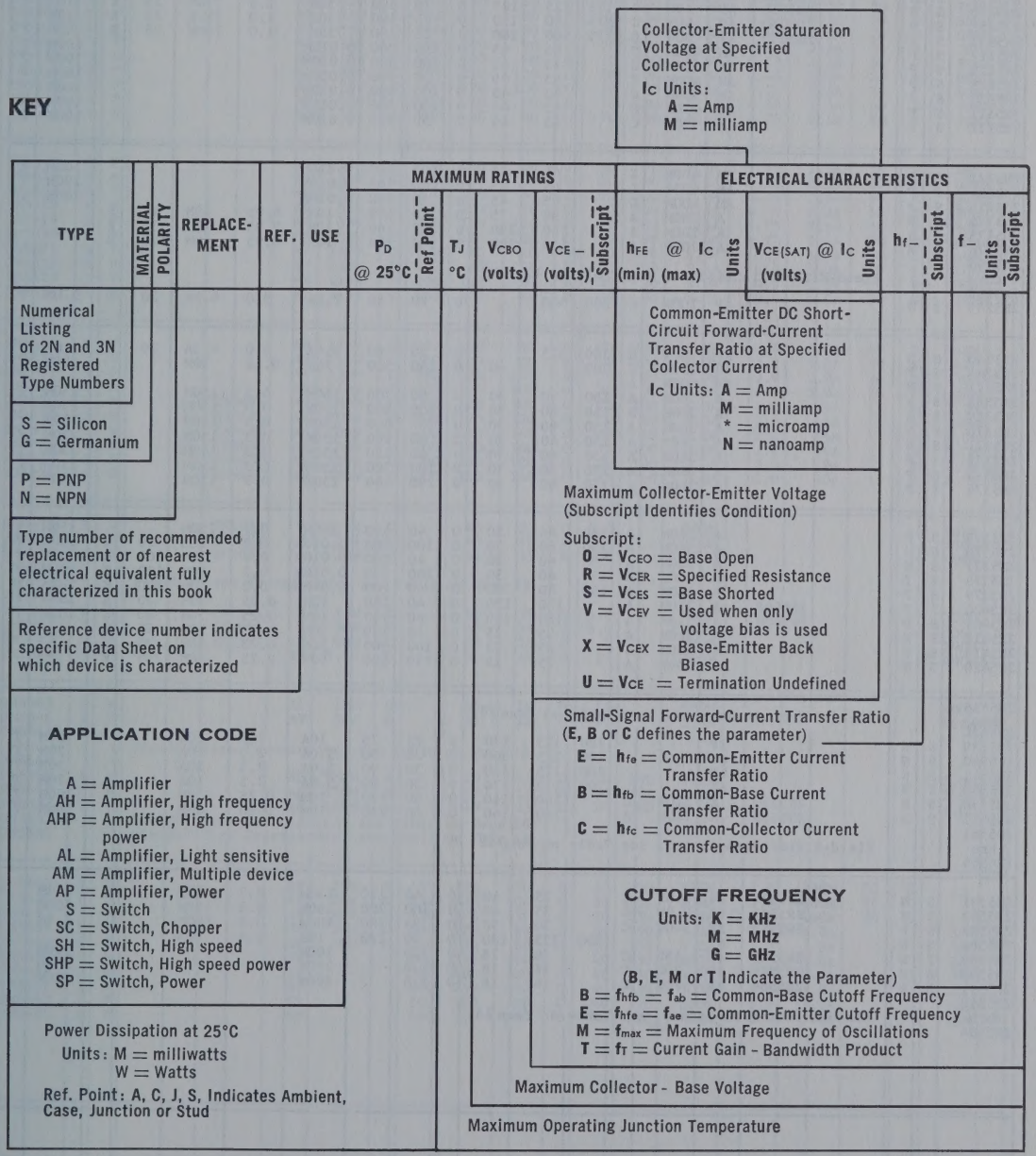
TRANSIENT SUPPRESSOR DIODES INDEX

TYPE	MATERIAL	REPLACEMENT	REFERENCE	$V_{(BR)R}$ @ I_R Volts (min)	mAdc	V_{RM} Volts (wkg)	V_R Volts	i_R (surge) AMP (max)	TC %/°C (max)
1N5555	S	1N2991B	1N2970	33	0.005	21.5	30.5	-	0.093
1N5556	S	1N2995B	1N2970	43.7	0.005	28.5	40.3	-	0.094
1N5557	S	1N2997B	1N2970	54	0.005	34.5	49	-	0.096
1N5558	S	1N3015B	1N2970	191	0.005	124	175	-	0.100
1N5629	S	1N2970A	1N2970	6.12	10	5.5	10.8	139	0.057
1N5629A	S	1N2970B	1N2970	6.45	10	5.8	10.5	143	0.057
1N5630	S	1N2971A	1N2970	6.75	10	6.05	11.7	128	0.061
1N5630A	S	1N2971B	1N2970	7.13	10	6.40	11.3	132	0.061
1N5631	S	1N2972A	1N2970	7.38	10	6.63	12.5	120	0.065
1N5631A	S	1N2972B	1N2970	7.79	10	7.02	12.1	124	0.065
1N5632	S	1N2973A	1N2970	8.19	1.0	7.37	13.8	109	0.068
1N5632A	S	1N2973B	1N2970	8.65	1.0	7.78	13.4	112	0.068
1N5633	S	1N2974A	1N2970	9.0	1.0	8.10	15	100	0.073
1N5633A	S	1N2974B	1N2970	9.5	1.0	8.55	1.45	103	0.073
1N5634	S	1N2975A	1N2970	9.9	1.0	8.92	16.2	93	0.075
1N5634A	S	1N2975B	1N2970	10.5	1.0	9.40	15.6	96	0.075
1N5635	S	1N2976A	1N2970	10.8	1.0	9.72	17.3	87	0.078
1N5635A	S	1N2976B	1N2970	11.4	1.0	10	16.7	90	0.078
1N5636	S	1N2977A	1N2970	11.7	1.0	10.5	19	79	0.081
1N5636A	S	1N2977B	1N2970	12.4	1.0	11.1	18.2	82	0.081
1N5637	S	1N2979A	1N2970	13.5	1.0	12.1	22	68	0.084
1N5637A	S	1N2979B	1N2970	14.3	1.0	12.8	21.2	71	0.084
1N5638	S	1N2980A	1N2970	14.4	1.0	12.9	23.5	64	0.086
1N5638A	S	1N2980B	1N2970	15.2	1.0	13.6	22.5	67	0.086
1N5639	S	1N2982A	1N2970	16.2	1.0	14.5	26.5	56.5	0.088
1N5639A	S	1N2982B	1N2970	17.1	1.0	15.3	25.2	59.5	0.088
1N5640	S	1N2984A	1N2970	18	1.0	16.2	29.1	51.5	0.090
1N5640A	S	1N2984B	1N2970	19	1.0	17.1	27.7	54	0.090
1N5641	S	1N2985A	1N2970	19.8	1.0	17.8	31.9	47	0.092
1N5641A	S	1N2985B	1N2970	20.9	1.0	18.8	30.6	49	0.092
1N5642	S	1N2986A	1N2970	21.6	1.0	19.4	34.7	43	0.094
1N5642A	S	1N2986B	1N2970	22.8	1.0	20.5	33.2	45	0.094
1N5643	S	1N2988A	1N2970	24.3	1.0	21.8	39.1	38.5	0.096
1N5643A	S	1N2988B	1N2970	25.7	1.0	23.1	37.5	40	0.096
1N5644	S	1N2989A	1N2970	27	1.0	24.3	43.5	34.5	0.097
1N5644A	S	1N2989B	1N2970	28.5	1.0	25.6	41.4	36	0.097
1N5645	S	1N2990A	1N2970	29.7	1.0	26.8	47.7	31.5	0.098
1N5645A	S	1N2990B	1N2970	31.4	1.0	28.2	45.7	33	0.098
1N5646	S	1N2991A	1N2970	32.4	1.0	29.1	52	29	0.099
1N5646A	S	1N2991B	1N2970	34.2	1.0	30.8	49.9	30	0.099
1N5647	S	1N2992A	1N2970	35.1	1.0	31.6	56.4	26.5	0.100
1N5647A	S	1N2992B	1N2970	37.1	1.0	33.3	53.9	28	0.100
1N5648	S	1N2993A	1N2970	38.7	1.0	34.8	61.9	24	0.101
1N5648A	S	1N2993B	1N2970	40.9	1.0	36.8	59.3	25.3	0.101
1N5649	S	1N2995A	1N2970	42.3	1.0	38.1	67.8	22.2	0.101
1N5649A	S	1N2995B	1N2970	44.7	1.0	40.2	64.8	23.2	0.101
1N5650	S	1N2997A	1N2970	45.9	1.0	41.3	73.5	20.4	0.102
1N5650A	S	1N2997B	1N2970	48.5	1.0	43.6	70.1	21.4	0.102
1N5651	S	1N2999A	1N2970	50.4	1.0	45.4	80.5	18.6	0.103
1N5651A	S	1N2999B	1N2970	53.2	1.0	47.8	77	19.5	0.103
1N5652	S	1N3000A	1N2970	55.8	1.0	50.2	89	16.9	0.104
1N5652A	S	1N3000B	1N2970	58.9	1.0	53	85	17.7	0.104
1N5653	S	1N3001A	1N2970	61.2	1.0	55.1	98	15.3	0.104
1N5653A	S	1N3001B	1N2970	64.6	1.0	58.1	92	16.3	0.104
1N5654	S	1N3002A	1N2970	67.5	1.0	60.7	108	13.9	0.105
1N5654A	S	1N3002B	1N3970	71.3	1.0	64.1	103	14.6	0.105
1N5655	S	1N3003A	1N2970	73.8	1.0	66.4	118	12.7	0.105
1N5655A	S	1N3003B	1N2970	77.9	1.0	70.1	113	13.3	0.105
1N5656	S	1N3004A	1N2970	81.9	1.0	73.7	131	11.4	0.106
1N5656A	S	1N3004B	1N2970	86.5	1.0	77.8	125	12	0.106
1N5657	S	1N3005A	1N2970	90	1.0	81	144	10.4	0.106
1N5657A	S	1N3005B	1N2970	95	1.0	85.5	137	11	0.106
1N5658	S	1N3007A	1N2970	99	1.0	89.2	158	9.5	0.107
1N5658A	S	1N3007B	1N2970	105	1.0	94	152	9.9	0.107
1N5659	S	1N3008A	1N2970	108	1.0	97.2	173	8.7	0.107
1N5659A	S	1N3008B	1N2970	114	1.0	102	165	9.1	0.107
1N5660	S	1N3009A	1N2970	117	1.0	105	187	8.0	0.107
1N560A	S	1N3009B	1N2970	124	1.0	111	179	8.4	0.107
1N5661	S	1N3011A	1N2970	135	1.0	121	215	7.0	0.108
1N5661A	S	1N3011B	1N2970	143	1.0	128	207	7.2	0.108
1N5662	S	1N3012A	1N2970	144	1.0	130	230	6.5	0.108
1N5662A	S	1N3012B	1N2970	152	1.0	136	219	6.8	0.108
1N5663	S	1N3013A	1N2970	153	1.0	138	244	6.2	0.108
1N5663A	S	1N3013B	1N2970	162	1.0	145	234	6.4	0.108
1N5664	S	1N3014A	1N2970	162	1.0	146	258	5.8	0.108
1N5664A	S	1N3014B	1N2970	171	1.0	154	246	6.1	0.108
1N5665	S	1N3015A	1N2970	180	1.0	162	287	5.2	0.108
1N5665A	S	1N3015B	1N2970	190	1.0	171	274	5.5	0.108

NUMERICAL INDEX

Numerical Listing of EIA-Registered 2N and 3N Type Numbers and Short-Form specifications for devices introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY


Collector-Emitter Saturation Voltage at Specified Collector Current
Ic Units:
A = Amp
M = milliamp
TYPE
MATERIAL
POLARITY
REPLACE-MENT
REF.
USE
MAXIMUM RATINGS
ELECTRICAL CHARACTERISTICS
PD @ 25°C
Ref Point
TJ °C
VCBO (volts)
VCE – (volts)
Subscript
hFE @ Ic (min) (max)
Units
VCE(SAT) @ Ic (volts)
Units
hf –
Subscript
f –
Units
Subscript
Numerical Listing of 2N and 3N Registered Type Numbers
S = Silicon
G = Germanium
P = PNP
N = NPN
Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book
Reference device number indicates specific Data Sheet on which device is characterized
Common-Emitter DC Short-Circuit Forward-Current Transfer Ratio at Specified Collector Current
Ic Units: A = Amp
M = milliamp
* = microamp
N = nanoamp
Maximum Collector-Emitter Voltage (Subscript Identifies Condition)
Subscript:
O = VCEO = Base Open
R = VCER = Specified Resistance
S = VCES = Base Shorted
V = VCEV = Used when only voltage bias is used
X = VCEX = Base-Emitter Back Biased
U = VCE = Termination Undefined
Small-Signal Forward-Current Transfer Ratio (E, B or C defines the parameter)
E = hfe = Common-Emitter Current Transfer Ratio
B = hfb = Common-Base Current Transfer Ratio
C = hfc = Common-Collector Current Transfer Ratio
APPLICATION CODE
A = Amplifier
AH = Amplifier, High frequency
AHP = Amplifier, High frequency power
AL = Amplifier, Light sensitive
AM = Amplifier, Multiple device
AP = Amplifier, Power
S = Switch
SC = Switch, Chopper
SH = Switch, High speed
SHP = Switch, High speed power
SP = Switch, Power
CUTOFF FREQUENCY
Units: K = KHz
M = MHz
G = GHz
(B, E, M or T Indicate the Parameter)
B = fhfb = fab = Common-Base Cutoff Frequency
E = fhfe = fae = Common-Emitter Cutoff Frequency
M = fmax = Maximum Frequency of Oscillations
T = fT = Current Gain - Bandwidth Product
Power Dissipation at 25°C
Units: M = milliwatts
W = Watts
Ref. Point: A, C, J, S, Indicates Ambient, Case, Junction or Stud
Maximum Collector - Base Voltage
Maximum Operating Junction Temperature

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N3684A thru 2N3687A			Field-Effect Transistors, see Table on Page 18																
2N3740A	S	P		2N3740	AP	25W	C	200	60	60	0	30	100	250M	0.6	1.0A	25	E	4.0M	
2N3741A	S	P		2N3740	AP	25W	C	200	80	80	0	30	100	250M	0.6	1.0A	25	E	4.0M	
2N4091A thru 2N4093A			Field-Effect Transistors, see Table on Page 18																
2N4877	S	N			SP	10W	C	200	70	60	0	20	100	4.0A	1.0	4.0A	4.0	E		
2N5031	S	N		2N5031	AH	200M	A		15	10	0	25	300	1.0M					1000M	T
2N5032	S	N		2N5031	AH	200M	A		15	10	0	25	300	1.0M					1000M	T
2N5050	S	N		2N5050	AP	40W	C	175	125	125	0	25	100	750M	1.0	750M	25	E	10M	T
2N5051	S	N		2N5050	AP	40W	C	175	150	150	0	25	100	750M	1.0	750M	25	E	10M	T
2N5052	S	N		2N5050	AP	40W	C	175	200	200	0	25	100	750M	1.0	750M	25	E	10M	T
2N5117	S	P			AM	400M	C		45	45	0	100	300	0.010M					100M	T
2N5118	S	P			AM	400M	C		45	45	0	100	300	0.010M					100M	T
2N5119	S	P			AM	400M	C		45	45	0	50	800	0.010M					100M	T
2N5120	S	P			AM	300M	C		45	45	0	100	300	0.010M					100M	T
2N5121	S	P			AM	300M	C		45	45	0	100	300	0.010M					100M	T
2N5122	S	P			AM	300M	C		45	45	0	50	800	0.010M					100M	T
2N5123	S	P			AM	400M	C		45	45	0	100	300	0.010M					100M	T
2N5124	S	P			AM	400M	C		45	45	0	100	300	0.010M					100M	T
2N5125	S	P			AM	400M	C		45	45	0	50	800	0.010M					100M	T
2N5174	S	N			A	200M	A		90	75	0	40	600	10M	0.95	10M	40	E		
2N5175	S	N			A	200M	A		130	100	0	55	160	10M	0.95	10M	55	E		
2N5176	S	N			A	200M	A		130	100	0	140	300	10M	0.95	10M	140	E		
2N5196 thru 2N5199			Field-Effect Transistors, see Table on Page 18																
2N5239	S	N			AP	100W	C	200	300		0	20	80	2.0A	5.0	4.5A	20	E	5.0M	T
2N5240	S	N			AP	100W	C	200	375		0	20	80	2.0A	5.0	4.5A	20	E	5.0M	T
2N5244	S	P			SH	1.0W	C	200		40	0	150	300	10M	0.12	10M			450M	T
2N5271	S	N			SH	600M	A													T
2N5368	S	N			A	360M	A	150	60	30	0	60	200	150M	0.3	150M			250M	T
2N5369	S	N			A	360M	A	150	60	30	0	100	300	150M	0.3	150M			250M	T
2N5370	S	N			A	360M	A	150	60	30	0	200	600	150M	0.3	150M			250M	T
2N5371	S	N			A	360M	A	150	40	30	0	60	600	150M	0.3	150M			250M	T
2N5372	S	P			A	360M	A	150	60	30	0	40	120	150M	0.3	150M			150M	T
2N5373	S	P			A	360M	A	150	60	30	0	100	300	150M	0.3	150M			150M	T
2N5374	S	P			A	360M	A	150	60	30	0	200	400	150M	0.3	150M			150M	T
2N5375	S	P			A	360M	A	150	40	30	0	40	400	150M	0.3	150M			150M	T
2N5376	S	N			A	360M	A	150	60	30	0	100	500	0.010M	0.2	10M	120	E	300M	T
2N5377	S	N			A	360M	A	150	60	30	0	40	200	0.010M	0.2	10M	100	E	300M	T
2N5378	S	P			A	360M	A	150	40	30	0	100	500	0.010M	0.2	10M	120	E	200M	T
2N5379	S	P			A	360M	A	150	40	30	0	40	200	0.010M	0.2	10M	100	E	200M	T
2N5400	S	P		2N5400	A	310M	A		130	120	0	40	180	10M	0.25	50M	30	E	100M	T
2N5401	S	P		2N5400	A	310M	A		160	150	0	60	240	10M	0.25	50M	40	E	100M	T
2N5418	S	N			A	360M	A		25	25	0	40	120	50M	0.25	50M	25	E		
2N5419	S	N			A	360M	A		25	25	0	100	300	50M	0.25	50M	70	E		
2N5420	S	N			A	360M	A		25	25	0	250	500	50M	0.25	50M	150	E		
2N5515 thru 2N5524			Field-Effect Transistors, see Table on Page 18																
2N5539	S	N			SP			200	175	130	0	25	75	10A	3.0	20A			20M	T
2N5540	S	N			SP			200	325	300	0	20	60	5.0A	2.5	10A			20M	T
2N5541	S	N			SP			200	175	130	0	30	90	5.0A	2.5	10A			20M	T
2N5542	S	N			SP			200	175	130	0	30	90	5.0A	2.5	10A			20M	T
2N5550	S	N		2N5550	A	310M	A		160	140	0	60	250	10M	0.25	50M			100M	T
2N5551	S	N		2N5550	A	310M	A		180	160	0	80	250	10M	0.20	50M			100M	T
2N5561 thru 2N5566			Field-Effect Transistors, see Table on Page 18																
2N5581	S	N		2N5581	SH	2.0W	C		75	40	0	40	120	150M	0.3	150M			250M	
2N5582	S	N		2N5581	SH	2.0W	C		75	40	0	100	300	150M	0.3	150M			300M	
2N5583	S	P		2N5581	SH	5.0W	C		30	30	0	25	100	100M	0.8	100M			1.3G	
2N5584	S	N			SP			200	225	180	0	40	120	10A	1.8	20A				
2N5589	S	N		2N5589	AP	15W	C		36	18	0	5.0		100M					200M	
2N5590	S	N		2N5589	AP	30W	C		36	18	0	5.0		250M					200M	
2N5591	S	N		2N5589	AP	70W	C		36	18	0	5.0		200M					200M	
2N5592 thru 2N5594			Field-Effect Transistors, see Table on Page 18																

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N5595	S	N			AP	30W	C	200	55	30	0	20		50M					1.5G	T
2N5596	S	N			AP	40W	C	200	55	30	0	20		50M					1.5G	T
2N5597	S	P			AP	20W	C	200	80	60	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5598	S	N			AP	20W	C	200	80	60	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5599	S	P			AP	20W	C	200	100	80	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5600	S	N			AP	20W	C	200	100	80	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5601	S	P			AP	20W	C	200	100	80	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5602	S	N			AP	20W	C	200	100	80	0	70	200	1.0A	0.46	1.0A	50	E	60M	T
2N5603	S	P			AP	20W	C	200	120	100	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5604	S	N			AP	20W	C	200	120	100	0	30	90	1.0A	0.46	1.0A	20	E	50M	T
2N5605	S	P			AP	25W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5606	S	N			AP	25W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5607	S	P			AP	25W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5608	S	N			AP	25W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5609	S	P			AP	25W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5610	S	N			AP	25W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5611	S	P			AP	25W	C	200	120	100	0	30	90	2.5A	1.45	2.5A	20	E	60M	T
2N5612	S	N			AP	25W	C	200	120	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5613	S	P			AP	58W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5614	S	N			AP	58W	C	200	80	60	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5615	S	P			AP	58W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5616	S	N			AP	58W	C	200	100	80	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5617	S	P			AP	58W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5618	S	N			AP	58W	C	200	100	80	0	70	200	2.5A	0.75	2.5A	50	E	70M	T
2N5619	S	P			AP	58W	C	200	120	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5620	S	N			AP	58W	C	200	120	100	0	30	90	2.5A	0.75	2.5A	20	E	60M	T
2N5621	S	P			AP	116W	C	200	80	60	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5622	S	N			AP	116W	C	200	80	60	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5623	S	P			AP	116W	C	200	100	80	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5624	S	N			AP	116W	C	200	100	80	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5625	S	P			AP	116W	C	200	100	80	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5626	S	N			AP	116W	C	200	100	80	0	70	200	5.0A	0.9	5.0A	50	E	40M	T
2N5627	S	P			AP	116W	C	200	120	100	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5628	S	N			AP	116W	C	200	120	100	0	30	90	5.0A	0.9	5.0A	20	E	30M	T
2N5629	S	N		2N5629	AP	200W	C	200	100	100	0	25	100	8.0A	2.0	16A	15	E	1.0M	T
2N5630	S	N		2N5629	AP	200W	C	200	120	120	0	20	80	8.0A	2.0	16A	15	E	1.0M	T
2N5631	S	N		2N5629	AP	200W	C	200	140	140	0	15	60	8.0A	2.0	16A	15	E	1.0M	T
2N5632	S	N		2N5632	AP	150W	C	200	100	100	0	25	100	5.0A	2.0	10A	15	E	1.0M	T
2N5633	S	N		2N5632	AP	150W	C	200	120	120	0	20	180	5.0A	2.0	10A	15	E	1.0M	T
2N5634	S	N		2N5632	AP	150W	C	200	140	140	0	15	60	5.0A	2.0	10A	15	E	1.0M	T
2N5635	S	N		2N5635	A	7.5W	C		60	35	0	5.0		100M					500M	T
2N5636	S	N		2N5635	A	15W	C		60	35	0	5.0		200M					450M	T
2N5637	S	N		2N5635	A	30W	C		60	35	0	5.0		500M					400M	T
2N5638 thru 2N5640	Field-Effect Transistors, see Table on Page 18																			
2N5641	S	N		2N5641	A	15W	C		65	35	0	5.0		100M					300M	T
2N5642	S	N		2N5641	A	30W	C		65	35	0	5.0		200M					250M	T
2N5643	S	N		2N5641	A	60W	C		65	35	0	5.0		200M					200M	T
2N5644	S	N			AP	3.5W	C		36	18	0	15		100M					400M	T
2N5645	S	N			AP	12W	C		36	18	0	15		500M					400M	T
2N5646	S	N			AP	30W	C		36	18	0	15		1.0A					400M	T
2N5647 thru 2N5649	Field-Effect Transistors, see Table on Page 18																			
2N5650	S	N			AH	150M	A		20	15	0	30	300	3.0M					2.0G	T
2N5651	S	N			AH	150M	A		20	15	0	30	300	3.0M					2.0G	T
2N5652	S	N			AH	150M	A		20	15	0	30	300	3.0M					2.0G	T
2N5653	Field-Effect Transistors, see Table on Page 18																			
2N5654	Field-Effect Transistors, see Table on Page 18																			
2N5655	S	N			AP	20W	C	150	275	250	0	30	250	100M	1.0	100M	20	E		
2N5656	S	N			AP	20W	C	150	325	300	0	30	250	100M	1.0	100M	20	E		
2N5657	S	N			AP	20W	C	150	375	350	0	30	250	100M	1.0	100M	20	E		
2N5658	S	N			SP	30W	C	200	120	80	0	50	150	5.0A	1.0	1.0A			30M	T
2N5659	S	N			SP	30W	C	200	120	80	0	50	150	5.0A	1.0	1.0A			30M	T
2N5660	S	N			SP			200	250	200	0	40	150	500M	0.4	1.0A			20M	T
2N5661	S	N			SP			200	400	300	0	40	150	500M	0.4	1.0A			20M	T
2N5662	S	N			SP			200	250	200	0	40	150	500M	0.4	1.0A			20M	T
2N5663	S	N			SP			200	400	300	0	40	150	500M	0.4	1.0A			20M	T
2N5664	S	N			SP			200	250	200	0	40	120	1.0A	0.4	3.0A			20M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N5665	S	N			SP			200	400	300	0	40	120	1.0A	0.4	3.0A			20M	T
2N5666	S	N			SP			200	250	200	0	40	120	1.0A	0.4	3.0A			20M	T
2N5667	S	N			SP			200	400	300	0	40	120	1.0A	0.4	3.0A			20M	T
2N5668 thru 2N5670	Field-Effect Transistors, see Table on Page 18																			
2N5679	S	P		2N5679	AP	10W	C	200	100	100	0	40	150	250M	0.6	250M	40	E	30M	T
2N5679	S	P		2N5679	AP	10W	C	200	120	120	0	40	150	250M	0.6	250M	40	E	30M	T
2N5680	S	P		2N5681	AP	10W	C	200	100	100	0	40	150	250M	0.6	250M	40	E	30M	T
2N5681	S	N		2N5681	AP	10W	C	200	120	120	0	40	150	250M	0.6	250M	40	E	30M	T
2N5682	S	N																		
2N5683	S	P		2N5683	AP	300W	C	200	60	60	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5684	S	P		2N5683	AP	300W	C	200	80	80	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5685	S	N		2N5685	AP	300W	C	200	60	60	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5686	S	N		2N5685	AP	300W	C	200	80	80	0	15	60	25A	5.0	50A	15	E	2.0M	T
2N5687	S	N			AP	5.0W	C		40	20	0	15		50M						
2N5688	S	N			AP	10W	C		40	20	0	15		50M						
2N5689	S	N			AP	25W	C		60	40	0	15		100M						
2N5690	S	N			AP	50W	C		50	30	0	10		100M						
2N5691	S	N			AP	88W	C		50	30	0	10		100M						
2N5692	G	P			AP	125W	C	110	50	30	0	20	65	25A	0.75	60A			200M	T
2N5693	G	P			SP	125W	C	110	80	60	0	20	65	25A	0.75	60A			200M	T
3N5694	G	P			SP	125W	C	110	100	80	0	20	65	25A	0.75	60A			200M	T
2N5695	G	P			SP	125W	C	110	120	100	0	20	65	25A	0.75	60A			200M	T
2N5696	G	P			SP	125W	C	110	140	120	0	20	65	25A	0.75	60A			200M	T
2N5697	S	N			AP	3.5W	C		40	18	0	30		40M						
2N5698	S	N			AP	5.0W	C		40	18	0	30		40M						
2N5699	S	N			AP	10W	C		40	18	0	15		50M						
2N5700	S	N			AP	35W	C		40	18	0	30		50M						
2N5701	S	N			AP	35W	C		40	18	0	30		50M						
2N5702	S	N			AP	880M	C		40	18	0	15		50M						
2N5703	S	N			AP	750M	C		40	18	0	15		50M						
2N5704	S	N			AP	25W	C		40	18	0	15		50M						
2N5705	S	N			AP	44W	C		36	18	0	15		100M						
2N5706	S	N			AP	80W	C		36	18	0	15		100M						
2N5707	S	N			AP	70W	S	200	70	50	0	5.0	50	100M					50M	T
2N5708	S	N			AP	100W	S	200	70	50	0	5.0	50	100M					50M	T
2N5709	S	N			AP	140W	S	200	70	50	0	5.0	50	200M					50M	T
2N5710	S	N			AP	3.5W	C		40	20	0	20		10M						
2N5711	S	N			AP	10W	C		60	36	0	20		50M						
2N5712	S	N			AP	25W	C		60	40	0	10		100M						
2N5713	S	N			A	45W	C		60	40	0	10		10M						
2N5714	S	N			A	45W	C		60	40	0	10		10M						
2N5715	S	N			AP	6.0W	S		50	3.0	0	20	200	50M					3.5W	T
2N5716 thru 2N5718	Field-Effect Transistors, see Table on Page 18																			
2N5729	S	N			SP			200	100	80	0	30	300	2.0A	1.5	5.0A	1.5	E	30M	T
2N5730	S	N			SP			200	100	80	0	30	300	2.0A	1.2	5.0A	1.5	E	30M	T
2N5731	S	N			SP			200	100	80	0	30	300	5.0A	1.5	10A	1.5	E	30M	T
2N5732	S	N			SP			200	100	80	0	30	300	5.0A	1.2	10A	1.5	E	30M	T
2N5733	S	N			SP			200	100	80	0	30	300	10A	1.2	20A	1.5	E	30M	T
2N5734	S	N			SP			200	100	80	0	30	300	10A	1.2	20A	1.5	E	30M	T
2N5735	S	N			SH	360M	A		60	30	0	40	120	150M	0.4	150M			200M	T
2N5736	S	N			SH	360M	A		60	30	0	100	300	150M	0.4	150M			200M	T
2N5737	S	P			AP			200	60	60	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5738	S	P			AP			200	100	100	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5739	S	P			AP			200	60	60	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5740	S	P			AP			200	100	100	0	20	80	5.0A	0.5	5.0A	20	E	10M	T
2N5741	S	P			AP			200	60	60	0	20	80	10A	1.5	10A	20	E	10M	T
2N5742	S	P			AP			200	100	100	0	20	80	10A	1.5	10A	20	E	10M	T
2N5743	S	P			AP			200	60	60	0	20	80	10A	1.5	10A	20	E	10M	T
2N5744	S	P			AP			200	100	100	0	20	80	10A	1.5	10A	20	E	10M	T
2N5745	S	P			AP	200W	C	200	80	80	0	15	60	10A	1.0	10A	40	E	2.0M	T
2N5758	S	N			AP	150W	C	200	100	100	0	25	100	3.0A	1.0	3.0A	15	E	1.0M	T
2N5759	S	N			AP	150W	C	200	120	120	0	20	80	3.0A	1.0	3.0A	15	E	1.0M	T
2N5760	S	N			AP	150W	C	200	140	140	0	15	60	3.0A	1.0	3.0A	15	E	1.0M	T
2N5761	S	N			AH	250M	A		20	15	0	30	300	10M			18.5	E		
2N5762	S	N			AH	300M	A		20	15	0	30	300	15M			16.5	E		
2N5763	S	P			SP	400M	A		65	60	0	70		10M	0.4	150M			200M	T
2N5764	S	N			AH	10W	S		55	25	0	20		0.10A						

TYPE	MATERIAL	POLARITY	REPLACEMENT	REF.	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CB} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N5765	S	N			AH	19W	S		55	25	0	20		0.10A					
2N5766	S	N			AH	5.0W	S		55	25	0	20		0.05A					
2N5767	S	N			AH	10W	S		55	25	0	20		0.10A					
2N5768	S	N			AH	20W	S		55	25	0	20		0.10A					
2N5777	S	N			S	200M	A	100	25	25	0								
2N5778	S	N			S	200M	A	100	40	40	0								
2N5779	S	N			S	200M	A	100	25	25	0								
2N5780	S	N			S	200M	A	100	40	40	0								
2N5781	S	P			AP	10W	C	200	80	80	R	4.0		3.2A	2.0	3.2A	25	E	8.0M T
2N5782	S	P			AP	10W	C	200	65	65	R	4.0		3.2A	2.0	3.2A	25	E	8.0M T
2N5783	S	P			AP	10W	C	200	45	45	R	4.0		3.2A	2.0	3.2A	25	E	8.0M T
2N5784	S	N			AP	10W	C	200	80	80	R	4.0		3.2A	2.0	3.2A	25	E	2.5M T
2N5785	S	N			AP	10W	C	200	65	65	R	4.0		3.2A	2.0	3.2A	25	E	2.5M T
2N5786	S	N			AP	10W	C	200	45	45	R	4.0		3.2A	2.0	3.2A	25	E	2.5M T
2N5793	S	N			SH	500M	A		75	40	0	40	120	150M	0.9	300M			
2N5794	S	N			SH	500M	A		75	40	0	100	300	150M	0.9	300M			
2N5795	S	N			SH	500M	A		60	60	0	40	120	150M	1.6	500M			
2N5796	S	N			SH	500M	A		60	60	0	100	300	150M	1.6	500M			
2N5797 thru 2N5803			Field-Effect Transistors, see Table on Page 18																
2N5804	S	N			SP			200	300	300	X	10	100	5.0A	2.0	5.0A			15M T
2N5805	S	N			SP			200	375	375	X	10	100	5.0A	2.0	5.0A			15M T
2N5810	S	N			A	500M	A	135	35	25	0	60	200	2.0M	0.75	500M			
2N5811	S	N			A	500M	A	135	35	25	0	60	200	2.0M	0.75	500M			
2N5812	S	N			A	500M	A	135	35	25	0	150	500	2.0M	0.75	500M			
2N5813	S	P			A	500M	A	135	35	25	0	150	500	2.0M	0.75	500M			
2N5814	S	N			A	500M	A	135	50	40	0	60	120	2.0M	0.75	500M			
2N5815	S	P			A	500M	A	135	50	40	0	60	120	2.0M	0.75	500M			
2N5816	S	N			A	500M	A	135	50	40	0	100	200	2.0M	0.75	500M			
2N5817	S	P			A	500M	A	135	50	40	0	100	200	2.0M	0.75	500M			
2N5818	S	N			A	500M	A	135	50	40	0	150	300	2.0M	0.75	500M			
2N5819	S	P			A	500M	A	135	50	40	0	150	300	2.0M	0.75	500M			
2N5820	S	N			A	500M	A	135	70	60	0	60	120	2.0M	0.75	500M			
2N5821	S	P			A	500M	A	135	70	60	0	60	120	2.0M	0.75	500M			
2N5822	S	N			A	500M	A	135	70	60	0	100	200	2.0M	0.75	500M			
2N5823	S	P			A	500M	A	135	70	60	0	100	200	2.0M	0.75	500M			
2N5824	S	N			A	360M	A	125	50	40	0	60	120	2.0M	0.125	10M	60	E	
2N5825	S	N			A	360M	A	125	50	40	0	100	200	2.0M	0.125	10M	100	E	
2N5826	S	N			A	360M	A	125	50	40	0	150	300	2.0M					
2N5827	S	N			A	360M	A	125	50	40	0	250	500	2.0M					
2N5828	S	N			A	360M	A	125	50	40	0	400	800	2.0M					
2N5829	S	P			AH	200M	A	125	30	30	0	20	150	2.0M					
2N5835	S	N			SH	200M	A	125	15	10	0	25		10M					
2N5836	S	N			SH	2.0W	C		15	10	0	25		50M					
2N5837	S	N			SH	2.0W	C		10	5.0	0	25		100M					
2N5838	S	N			SP			200	275	275	X	8.0	40	3.0A	1.0	3.0A	5.0	E	
2N5839	S	N			SP			200	300	300	X	10	50	2.0A	1.5	2.0A	5.0	E	
2N5840	S	N			SP			200	375	375	X	10	50	2.0A	1.5	2.0A	5.0	E	
2N5902 thru 2N5909			Field-Effect Transistors, see Table on Page 18																
3N151 thru 3N186			Field-Effect Transistors, see Table on Page 18																
3N188 thru 3N191			Field-Effect Transistors, see Table on Page 18																

FIELD-EFFECT TRANSISTORS

INDEX AND SHORT-FORM SPECIFICATIONS

This table contains a numerical listing and short-form specifications for field-effect transistors with EIA-registered 2N and 3N numbers, introduced since the publication of the Motorola Semiconductor Data Book (4th Edition).

KEY

TYPE	POLARITY	CONST.	NEAREST EQUIV.	REF.	I_{DSS} Min mA	I_{DSS} Max mA (*nA)	I_{GSS} I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{ISS} pF	NF @ f dB μV^* / $\sqrt{Hz}$ Units	NOTE D = Dual MP = Matched Pair
Numerical Listing of Registered Type Numbers	N = n-channel P = p-channel	J = Junction FET M = MOS FET	Type number of nearest electrical equivalent fully characterized in this book	Reference device number indicates specific Data Sheet on which device is characterized	Minimum and Maximum Drain Current with gate connected to source		Maximum Gate Current (leakage) with drain connected to source *Maximum leakage from drain to gate with source open	Minimum Breakdown Voltage (Subscript defines conditions) GS = Gate to source, drain connection not specified GSS = Gate to source, drain connected to source GD = Gate to drain, source connection not specified GDS = Gate to drain, source connected to drain DGO = Drain to gate, source open DGS = Drain to gate, source connected to drain DS = Drain to source, gate connection not specified DSX = Drain to source, gate biased to cutoff or beyond		Minimum and Maximum Forward Transadmittance		Maximum Input Capacitance	Noise Figure in dB or *, $\mu V / \sqrt{Hz}$ at a specified frequency; frequency units: H = Hz, K = kHz, M = MHz	

FIELD-EFFECT TRANSISTORS INDEX

TYPE	POLARITY	CONST.	NEAREST EQUIVALENT	REF.	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{ISS} pF	NF @ f dB $\frac{\mu V^*}{\sqrt{Hz}}$	NF @ f Units	NOTE
					*nA					*mmhos					
2N3684A	N	J	2N4221A		2.5	7.5	0.1	50	GSS			4.0	0.5	100H	
2N3685A	N	J	2N4220A		1.0	3.0	0.1	50	GSS			4.0	0.5	100H	
2N3686A	N	J	2N4220A		0.4	1.2	0.1	50	GSS			4.0	0.5	100H	
2N3687A	N	J	2N4220A		0.1	0.5	0.1	50	GSS			4.0	0.5	100H	
2N4091A	N	J	2N4091		30		0.04	50	GSS			16			
2N4092A	N	J	2N4092		15		0.04	50	GSS			16			
2N4093A	N	J	2N4093		8.0		0.04	50	GSS			16			
2N5196	N	J			0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100H	
2N5197	N	J			0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100H	
2N5198	N	J			0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100H	
2N5199	N	J			0.7	7.0	0.025	50	GSS	1000	4000	6.0	1.0	100H	
2N5515	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	2.0	10H	MP
2N5516	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	2.0	10H	MP
2N5517	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	2.0	10H	MP
2N5518	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	2.0	10H	MP
2N5519	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	2.0	10H	
2N5520	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	1.0	10H	
2N5521	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	1.0	10H	
2N5522	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	1.0	10H	
2N5523	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	1.0	10H	
2N5524	N	J			0.5	7.5	0.250	40	GSS	500	1000	25	1.0	10H	
2N5561	N	J			1.0	10	0.1	50	GSS			7.0	1.0	10H	MP
2N5562	N	J			1.0	10	0.1	50	GSS			7.0	1.0	10H	MP
2N5563	N	J			1.0	10	0.1	50	GSS			7.0	1.0	10H	MP
2N5564	N	J			5.0	30	0.1	40	GSS			12	1.0	10H	MP
2N5565	N	J			5.0	30	0.1	40	GSS			12	1.0	10H	MP
2N5566	N	J			5.0	30	0.1	40	GSS			12	1.0	10H	MP
2N5592	N	J		2N5592	1.0	10	0.25	50	GSS			20	2.6	10H	
2N5593	N	J		2N5592	1.0	10	0.25	50	GSS			20	6.0	10H	
2N5594	N	J		2N5592	1.0	10	0.25	50	GSS			20	10	10H	
2N5638	N	J				50	1.0	30	GSS				10		
2N5639	N	J				25	1.0	30	GSS				10		
2N5640	N	J				5.0	1.0	30	GSS				10		
2N5647	N	J			0.3	0.6	0.01	50	GSS			3.0	1.0	1.0K	
2N5648	N	J			0.5	1.0	0.01	50	GSS			3.0	1.0	1.0K	
2N5649	N	J			0.8	1.6	0.01	50	GSS			3.0	1.0	1.0K	
2N5653	N	J			40		1.0	30	GSS			10	2.5		
2N5654	N	J			15		1.0	30	GSS			10	2.5		
2N5668	N	J		2N5668	1.0	5.0	2.0	25	GSS			7.0	2.5	100M	
2N5669	N	J		2N5668	4.0	10	2.0	25	GSS			7.0	2.5	100M	
2N5670	N	J		2N5669	8.0	20	2.0	25	GSS			7.0	2.5	100M	
2N5797	P	J			0.02	0.10	3.0	40	GSS	60*	225*	5.0			MP
2N5798	P	J			0.08	0.40	3.0	40	GSS	100*	440*	5.0			MP
2N5799	P	J			0.25	1.00	3.0	40	GSS	160*	500*	5.0			MP
2N5800	P	J			0.70	2.00	3.0	40	GSS	250*	700*	5.0			MP
2N5801	N	J			2.0	15	0.1	-40	GSS			15	1.0	100H	MP
2N5802	N	J			10	40	0.1	-40	GSS			15	1.0	100H	MP
2N5803	N	J			30	80	0.1	-40	GSS			15	1.0	100H	MP
2N5902	N	J			0.03	0.5	0.003	-40	GSS	70	250	3.0	1.0	100H	MP
2N5903	N	J			0.03	0.5	0.003	-40	GSS	70	250	3.0	1.0	100H	MP
2N5904	N	J			0.03	0.5	0.003	-40	GSS	70	250	3.0	1.0	100H	MP
2N5905	N	J			0.03	0.5	0.003	-40	GSS	70	250	3.0	1.0	100H	MP
2N5906	N	J			0.03	0.5	0.001	-40	GSS	70	250	3.0	1.0	100H	MP
2N5907	N	J			0.03	0.5	0.001	-40	GSS	70	250	3.0	1.0	100H	MP
2N5908	N	J			0.03	0.5	0.001	-40	GSS	70	250	3.0	1.0	100H	MP
2N5909	N	J			0.03	0.5	0.001	-40	GSS	70	250	3.0	1.0	100H	
3N151	P	M				-5.0*						12	10	100H	
3N162	P	M	MFE3003			150*						20			
3N163	P	M				0.2*	0.01					2.5			
3N164	P	M				0.4*	0.01					2.5			
3N165	P	M				0.2*	0.01					3.0			
3N166	P	M				0.2*	0.01					3.0			
3N167	P	M				-0.5*						35			
3N168	P	M				-1.0*						35			
3N169	N	M		3N169		10*						5.0			
3N170	N	M		3N169		10*						5.0			
3N171	N	M		3N169		10*						5.0			
3N172	P	M				0.4*						3.5			
3N173	P	M				10*						3.5			
3N174	P	M				5.0*	0.0025					4.0			
3N175	N	M				5.0*	0.2					5.0			
3N176	N	M				10*	0.2					5.0			
3N177	N	M				25*	0.2					7.0			
3N178	P	M				0.5*	0.2					3.5			
3N179	P	M				1.0*						4.5			
3N180	P	M				1.0*						5.0			
3N181	P	M				0.5*						25			
3N182	P	M				2.5*						25			
3N183	P	M				10*						30			
3N184	P	M				2.0*						9.0			
3N185	P	M				5.0*						10			
3N186	P	M				10*						11			
3N188	P	M				0.2*						4.5			
3N189	P	M				0.2*						4.5			
3N190	P	M				0.2*	0.01					4.5			
3N191	P	M				0.2*	0.01					4.5			

DEVICE INDEX

DEVICE INDEX

Devices characterized in this supplement are identified by a 2 in the supplement column. A 1 in the supplement column denotes devices characterized in Supplement 1 – all other devices are characterized in the Semiconductor Data Book – 4th Edition. The reference number is not the replacement type number. The number shown in the reference column indicates the first device number listed on the page in the Data Book or Supplement where the device is characterized.

DEVICE	REFERENCE	SUPP.
1N91	1N91	
1N92	1N91	
1N93	1N91	
1N248B,C	1N248B	
1N249B,C	1N248B	
1N250B,C	1N248B	
1N429	1N429	
1N746,A	1N702	
1N747,A	1N702	
1N748,A	1N702	
1N749,A	1N702	
1N750,A	1N702	
1N751,A	1N702	
1N752,A	1N702	
1N753,A	1N702	
1N754,A	1N702	
1N755,A	1N702	
1N756,A	1N702	
1N757,A	1N702	
1N758,A	1N702	
1N759,A	1N702	
1N816	1N816	
1N821,A	1N821	
1N823,A	1N821	
1N825,A	1N821	
1N827,A	1N821	
1N829,A	1N821	
1N935,A,B	1N935	
1N936,A,B	1N935	
1N937,A,B	1N935	
1N938,A,B	1N935	
1N939,A,B	1N935	
1N941,A,B	1N941	
1N942,A,B	1N941	
1N943,A,B	1N941	
1N944,A,B	1N941	
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1N986	1N957	

DEVICE	REFERENCE	SUPP.
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1N1190	1N1183	
1N1191	1N248B	
1N1192	1N248B	
1N1193	1N248B	
1N1194	1N248B	
1N1195,A	1N248B	
1N1196,A	1N248B	
1N1197,A	1N248B	
1N1198,A	1N248B	
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1N1740,A	1N429	
1N1741,A	1N429	
1N1742,A	1N429	
1N2163,A	1N2163	
1N2164,A	1N2163	
1N2165,A	1N2163	
1N2166,A	1N2163	
1N2167,A	1N2163	
1N2168,A	1N2163	
1N2169,A	1N2163	
1N2170,A	1N2163	
1N2171,A	1N2163	
1N2382	1N1730	
1N2383	1N1730	
1N2384	1N1730	
1N2385	1N1730	
1N2620,A,B	1N2620	
1N2621,A,B	1N2620	
1N2622,A,B	1N2620	
1N2623,A,B	1N2620	

DEVICE	REFERENCE	SUPP.
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DEVICE	REFERENCE	SUPP.
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½M4.3AZ	½M2.4AZ	
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½M5.1AZ	½M2.4AZ	
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½M7.5Z	½M2.4AZ	
½M8.2Z	½M2.4AZ	
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.4M1.36FR2	1N816	
.4M2.04FR5	1N816	
.4M2.04FR2	1N816	
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1M120ZS10,5	1N4728	
1M130ZS10,5	1N4728	
1M150ZS10,5	1N4728	
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1M180ZS10,5	1N4728	
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MA202	MA200	

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MA1708	MA1702	
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MAC36-7	MAC35-1	2
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MCA2121	MCA1911	
MCA2122	MCA1911	

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MCR407	MCR407	1
MCR649	MCR649	
MCR729	MCR729	
MCR846	MCR846	
MCR1336	MCR1336	
MCR1718	MCR1718	
MCR1906	MCR1906	
MCR1907	MCR1907	
MCR2315	MCR2315	1
MCR2604	2N4151	
MCR2605	2N4151	
MCR2614L	MCR2315	1
MCR2818	MCR1907	
MCR2835	MCR2835	
MCR2918	MCR1907	
MCR2935	MCR2835	
MCR3818-1	MCR3818-1	2
MCR3818-2	MCR3818-1	2
MCR3818-3	MCR3818-1	2
MCR3818-4	MCR3818-1	2
MCR3818-5	MCR3818-1	2
MCR3818-6	MCR3818-1	2
MCR3818-7	MCR3818-1	2
MCR3818-8	MCR3818-1	2
MCR3835-1	MCR3835-1	2
MCR3835-2	MCR3835-1	2
MCR3835-3	MCR3835-1	2
MCR3835-4	MCR3835-1	2
MCR3835-5	MCR3835-1	2
MCR3835-6	MCR3835-1	2

DEVICE	REFERENCE	SUPP.
MCR3835-7	MCR3835-1	2
MCR3835-8	MCR3835-1	2
MCR3918-1	MCR3818-1	2
MCR3918-2	MCR3818-1	2
MCR3918-3	MCR3818-1	2
MCR3918-4	MCR3818-1	2
MCR3918-5	MCR3818-1	2
MCR3918-6	MCR3818-1	2
MCR3918-7	MCR3818-1	2
MCR3918-8	MCR3818-1	2
MCR3935-1	MCR3835-1	2
MCR3935-2	MCR3835-1	2
MCR3935-3	MCR3835-1	2
MCR3935-4	MCR3835-1	2
MCR3935-5	MCR3835-1	2
MCR3935-6	MCR3835-1	2
MCR3935-7	MCR3835-1	2
MCR3935-8	MCR3835-1	2
MD708	MD708	
MD918	MD918	
MD984	MD984	
MD986	MD986	
MD1120	MD1120	
MD1121	MD1120	
MD1122	MD1120	
MD1126	MD1126	
MD1127	MD1126	
MD1128	MD1128	
MD1129	MD1129	
MD1130	MD1130	
MD1131	MD1131	
MD1132	MD1132	
MD1134	MD1134	
MD2218	MD2218	1
MD2219	MD2219	1
MD2369	MD2369	
MD2904	MD2904	1
MD2905	MD2905	1
MD3133	MD3133	
MD3134	MD3133	
MD3250	MD3250	
MD3251	MD3251	
MD3467	MD3467	
MD3725	MD3725	
MD3762	MD3762	
MD4957	MD4957	
MD5000	MD5000	
MD6001	MD6001	
MD6002	MD6001	
MD6100	MD6100	
MDA920	MDA920	
MDA930	MDA920	
MDA940	MDA920	
MDA942	MDA942	
MDA950	MDA920	
MDA952	MDA942	
MDA960	MDA960	
MDA962	MDA942	
MDA970	MDA960	
MDA972	MDA942	
MDA980	MDA980	1
MDA990	MDA980	1
MDA1330H	MDA1330H	
MDA1331H	MDA1330H	
MDA1332H	MDA1330H	
MDA1333H	MDA1330H	
MDA1491	MDA942	
MDA1505	MDA942	
MDA1591	MDA942	
MF3304	MF3304	
MFE2000	MFE2000	
MFE2001	MFE2000	
MFE2004	MFE2004	
MFE2005	MFE2004	
MFE2006	MFE2004	
MFE2007	MFE2007	
MFE2008	MFE2007	

DEVICE	REFERENCE	SUPP.
MFE2009	MFE2007	
MFE2010	MFE2010	
MFE2011	MFE2010	
MFE2012	MFE2010	
MFE2093	MFE2093	
MFE2094	MFE2093	
MFE2095	MFE2093	
MFE2097	MFE2097	
MFE2098	MFE2097	
MFE2133	MFE2133	
MFE3001	MFE3001	
MFE3002	MFE3002	
MFE3003	MFE3003	
MFE3004	MFE3004	
MFE3005	MFE3004	
MFE3006	MFE3006	1
MFE3007	MFE3006	1
MFE3008	MFE3006	1
MFE4007	MFE4007	
MFE4008	MFE4007	
MFE4009	MFE4007	
MFE4010	MFE4007	
MFE4011	MFE4007	
MFE4012	MFE4007	
MJ400	MJ400	
MJ413	MJ413	
MJ420	MJ420	
MJ421	MJ420	
MJ423	MJ413	
MJ431	MJ413	
MJ450	MJ450	2
MJ480	MJ480	2
MJ481	MJ480	2
MJ490	MJ490	2
MJ491	MJ490	2
MJ500	MJ500	1
MJ501	MJ500	1
MJ802	MJ802	1
MJ1800	MJ1800	1
MJ2249	MJ2249	
MJ2250	MJ2249	
MJ2251	MJ2251	
MJ2252	MJ2251	
MJ2267	MJ2267	
MJ2268	MJ2267	
MJ2840	MJ2840	2
MJ2841	MJ2840	2
MJ2940	MJ2940	2
MJ2941	MJ2941	2
MJ3029	MJ3029	
MJ3030	MJ3029	
MJ3101	MJ2249	
MJ3201	MJ3201	
MJ3202	MJ3201	
MJ3771	2N3771	1
MJ3772	2N3771	1
MJ3801	MJ3801	1
MJ3802	MJ3801	1
MJ4502	MJ4502	1
MJ6700	MJ6700	1
MJ6701	MJ6700	1
MJ7000	MJ7000	1
MJ7200	MJ7200	1
MJ7201	MJ7200	1
MJ8100	MJ8100	1
MJ8101	MJ8100	1
MJ8400	MJ8400	1
MJ9000	MJ9000	1
MJC007	MJC007	2
MJC043	MJC007	2
MJC044	MJC007	2
MJC067	MJC007	2
MJC069	MJC007	2
MJC070	MJC007	2
MJC076	MJC007	2
MJC082	MJC007	2
MJE105	MJE105	

DEVICE	REFERENCE	SUPP.
MJE205	MJE205	
MJE340	MJE340	1
MJE341	MJE341	2
MJE344	MJE341	2
MJE370	MJE370	1
MJE371	MJE371	1
MJE520	MJE520	1
MJE521	MJE521	1
MJE2801	MJE2801	
MJE2901	MJE2901	
MJE2955	MJE2955	
MJE3055	MJE3055	
MLED600	MLED600	2
MM380	MM380	
MM404	MM404	2
MM404A	MM404A	2
MM709	MM709	
MM1139	MM1139	
MM1500	MM1500	
MM1501	MM1500	
MM1549	MM1549	
MM1550	MM1549	
MM1551	MM1549	
MM1557	MM1557	
MM1558	MM1557	
MM1559	MM1557	
MM1603	MM1603	
MM1619	MM1619	2
MM1620	MM1619	2
MM1748	MM1748	
MM1803	2N3137	
MM1812	MM1803	
MM1941	MM1941	
MM2258	MM2258	
MM2259	MM2258	
MM2260	MM2258	
MM2483	MM2483	
MM2484	MM2483	
MM2894	MM2894	
MM3000	MM3000	
MM3001	MM3000	
MM3002	MM3000	
MM3003	MM3000	
MM3008	MM3008	
MM3009	MM3008	
MM3724	MM3724	
MM3725	MM3724	
MM3726	MM3726	
MM3903	MM3903	1
MM3904	MM3903	1
MM3905	MM3905	1
MM3906	MM3905	1
MM4000	MM4000	
MM4001	MM4000	
MM4002	MM4000	
MM4003	MM4000	
MM4018	MM4018	2
MM4019	MM4019	2
MM4020	MM4020	2
MM4021	MM4020	2
MM4022	MM4020	2
MM4023	MM4020	2
MM4048	MM4048	
MM4049	MM4049	1
MM4052	MM4052	1
MM4261H	MM4261H	1
MM4429	MM4429	1
MM4430	MM4430	1
MM4545	MM4545	2
MM4546	MM4545	2
MM4547	MM4545	2
MM4645	MM4545	2
MM4646	MM4545	2
MM4647	MM4545	2
MM5000	MM5000	
MM5001	MM5000	
MM5002	MM5000	

DEVICE	REFERENCE	SUPP.
MM8000	MM8000	
MM8001	MM8000	
MM8002	MM8002	
MM8003	MM8003	
MM8006	MM8006	1
MM8007	MM8006	1
MM8008	MM8008	1
MM8009	MM8009	1
MM8010	MM8008	1
MM8011	MM8008	1
MM8012	MM8012	2
MMCD914	MMCD914	2
MMCD6100	MMCD914	2
MMCS709	MMCS709	2
MMCS910	MMCS910	2
MMCS918	MMCS910	2
MMCS929	MMCS910	2
MMCS930	MMCS910	2
MMCS0122	MMCS0122	2
MMCS0123	MMCS0122	2
MMCS0125	MMCS0122	2
MMCS0130	MMCS0122	2
MMCS0131	MMCS0122	2
MMCS0134	MMCS0122	2
MMCS0159	MMCS0159	2
MMCS0172	MMCS0172	2
MMCS2192	MMCS2192	2
MMCS2193	MMCS2192	2
MMCS2221	MMCS2192	2
MMCS2221A	MMCS2192	2
MMCS2222	MMCS2192	2
MMCS2222A	MMCS2192	2
MMCS2369	MMCS709	2
MMCS2369A	MMCS709	2
MMCS2483	MMCS910	2
MMCS2484	MMCS910	2
MMCS2857	MMCS0159	2
MMCS2894	MMCS709	2
MMCS2906	MMCS2192	2
MMCS2906A	MMCS2192	2
MMCS2907	MMCS2192	2
MMCS2907A	MMCS2192	2
MMCS3227	MMCS709	2
MMCS3250	MMCS2192	2
MMCS3250A	MMCS2192	2
MMCS3251	MMCS2192	2
MMCS3251A	MMCS2192	2
MMCS3252	MMCS709	2
MMCS3253	MMCS709	2
MMCS3444	MMCS709	2
MMCS3467	MMCS709	2
MMCS3468	MMCS709	2
MMCS3498	MMCS2192	2
MMCS3499	MMCS2192	2
MMCS3500	MMCS2192	2
MMCS3501	MMCS2192	2
MMCS3506	MMCS709	2
MMCS3507	MMCS709	2
MMCS3546	MMCS709	2
MMCS3634	MMCS2192	2
MMCS3635	MMCS2192	2
MMCS3636	MMCS2192	2
MMCS3637	MMCS2192	2
MMCS3724	MMCS709	2
MMCS3725	MMCS709	2
MMCS3734	MMCS709	2
MMCS3735	MMCS709	2
MMCS3762	MMCS709	2
MMCS3763	MMCS709	2
MMCS3798	MMCS910	2
MMCS3799	MMCS910	2
MMCS3866	MMCS0159	2
MMCS3903	MMCS2192	2
MMCS3904	MMCS2192	2
MMCS3905	MMCS2192	2
MMCS3906	MMCS2192	2

DEVICE	REFERENCE	SUPP.
MMCS3959	MMCS709	2
MMCS4260	MMCS709	2
MMCS4400	MMCS2192	2
MMCS4401	MMCS2192	2
MMCS4402	MMCS2192	2
MMCS4403	MMCS2192	2
MMCS5087	MMCS910	2
MMCS5088	MMCS910	2
MMCS5636	MMCS0159	2
MMD6050	MMD6050	
MMD6100	MMD6050	
MMD6150	MMD6050	
MMD7000	MMD6050	
MMD7001	MMD7001	1
MMF1	MMF1	
MMF2	MMF1	
MMF3	MMF1	
MMF4	MMF1	
MMF5	MMF1	
MMF6	MMF1	
MMT73	MMT73	2
MMT918	MMT918	
MMT930	MMT930	
MMT2222	MMT2222	
MMT2369	MMT2369	
MMT2484	MMT930	
MMT2857	MMT2857	
MMT2907	MMT2907	
MMT3014	MMT3014	1
MMT3546	MMT3546	
MMT3798	MMT3798	
MMT3799	MMT3798	
MMT3823	MMT3823	
MMT3903	MMT3903	
MMT3904	MMT3903	
MMT3905	MMT3905	
MMT3906	MMT3905	
MMT3960A	MMT3960A	
MMT8015	MMT8015	2
MP110	MP110	
MP110B	MP110B	
MP500	MP500	
MP501	MP500	
MP502	MP500	
MP504	MP500	
MP505	MP500	
MP506	MP500	
MP525	MP525	
MP600	MP600	
MP601	MP600	
MP602	MP600	
MP603	MP600	
MP800	MP800	
MP801	MP800	
MP900	MP900	
MP901	MP900	
MP902	MP900	
MP1612,A,B	MP1612	
MP1613	MP1613	
MP2000A	MP2000A	
MP2060	MP2060	
MP2061	MP2060	
MP2062	MP2060	
MP2063	MP2060	
MP2100A	MP2000A	
MP2200A	MP2000A	
MP2300A	MP2000A	
MP2400A	MP2000A	
MP3730	MP3730	
MP3731	MP3730	
MP5692	2N5692	2
MP5693	2N5692	2
MP5694	2N5692	2
MP5695	2N5692	2
MP5696	2N5692	2
MPF102	MPF102	
MPF108	MPF108	

DEVICE	REFERENCE	SUPP.
MPF109	MPF109	
MPF161	MPF161	
MPN3202	MPN3202	2
MPQ3303	MPQ3303	2
MPQ3725	MPQ3725	2
MPS404,A	MPS404	
MPS706,A	MPS706	
MPS834	MPS834	
MPS918	MPS918	
MPS2369	MPS2369	
MPS2711	MPS2711	
MPS2712	MPS2711	
MPS2713	MPS2713	
MPS2714	MPS2713	
MPS2923	MPS2923	
MPS2924	MPS2923	
MPS2925	MPS2923	
MPS2926	MPS2926	
MPS3392	MPS3392	
MPS3393	MPS3392	
MPS3394	MPS3392	
MPS3395	MPS3392	
MPS3563	MPS918	
MPS3638,A	MPS3638	
MPS3639	MPS3639	
MPS3640	MPS3640	
MPS3646	MPS3646	
MPS3693	MPS3693	
MPS3694	MPS3693	
MPS3702	MPS3702	
MPS3703	MPS3702	
MPS3704	MPS3704	
MPS3705	MPS3704	
MPS3706	MPS3704	
MPS3707	MPS3707	
MPS3708	MPS3707	
MPS3709	MPS3707	
MPS3710	MPS3707	
MPS3711	MPS3707	
MPS3721	MPS2926	
MPS5172	MPS5172	1
MPS6507	MPS6507	
MPS6511	MPS6511	
MPS6512	MPS6512	
MPS6513	MPS6512	
MPS6514	MPS6512	
MPS6515	MPS6512	
MPS6516	MPS6516	
MPS6517	MPS6516	
MPS6518	MPS6516	
MPS6519	MPS6516	
MPS6520	MPS6520	2
MPS6521	MPS6520	2
MPS6522	MPS6520	2
MPS6523	MPS6520	2
MPS6530	MPS6530	
MPS6531	MPS6530	
MPS6532	MPS6530	
MPS6533	MPS6530	
MPS6534	MPS6530	
MPS6535	MPS6530	
MPS6539	MPS6539	
MPS6540	MPS6540	
MPS6542	MPS6542	
MPS6543	MPS6543	
MPS6544	MPS6544	
MPS6545	MPS6544	
MPS6546	MPS6546	
MPS6547	MPS6546	
MPS6548	MPS6548	
MPS6560	MPS6560	
MPS6561	MPS6560	
MPS6562	MPS6560	
MPS6563	MPS6560	
MPS6565	MPS6565	
MPS6566	MPS6565	
MPS6567	MPS6567	

DEVICE	REFERENCE	SUPP.
MPS6568,A	MPS6568	1
MPS6569	MPS6568	1
MPS6570	MPS6568	1
MPS6571	MPS6571	
MPS-A05	MPS-A05	1
MPS-A06	MPS-A05	1
MPS-A09	MPS-A09	
MPS-A10	MPS-A10	1
MPS-A12	MPS-A12	
MPS-A13	MPS-A13	1
MPS-A14	MPS-A13	1
MPS-A20	MPS-A20	1
MPS-A55	MPS-A55	1
MPS-A56	MPS-A55	1
MPS-A65	MPS-A65	1
MPS-A66	MPS-A65	1
MPS-A70	MPS-A70	1
MPS-H02	MPS-H02	1
MPS-H04	MPS-H04	2
MPS-H05	MPS-H04	2
MPS-H10	MPS-H10	1
MPS-H11	MPS-H10	1
MPS-H20	MPS-H20	1
MPS-H30	MPS-H30	1
MPS-H31	MPS-H30	1
MPS-H32	MPS-H32	1
MPS-H37	MPS-H37	1
MPS-K10	MPS-A10	1
MPS-K11	MPS-A10	1
MPS-K12	MPS-A10	1
MPS-K20	MPS-A20	1
MPS-K21	MPS-A20	1
MPS-K22	MPS-A20	1
MPS-K70	MPS-A70	1
MPS-K71	MPS-A70	1
MPS-K72	MPS-A70	1
MPS-L01	MPS-L01	1
MPS-L07	MPS-L07	1
MPS-L08	MPS-L07	1
MPS-L51	MPS-L51	1
MPS-U01	MPS-U01	
MPS-U02	MPS-U02	
MPS-U03	MPS-U03	
MPS-U04	MPS-U03	
MPS-U05	MPS-U05	1
MPS-U06	MPS-U05	1
MPS-U10	MPS-U10	1
MPS-U51	MPS-U51	
MPS-U52	MPS-U52	
MPS-U55	MPS-U55	1
MPS-U56	MPS-U55	1
MPT20	MPT20	
MPT28	MPT28	
MPT32	MPT28	
MPZ5-16	MPZ5-16	
MPZ5-32	MPZ5-16	
MPZ5-180	MPZ5-16	
MQ2218	MD2218	1
MQ2219	MD2219	1
MQ2904	MD2904	1
MQ2905	MD2905	1
MQ3467	MD3467	
MQ3725	MD3725	
MQ3762	MD3762	
MQ3799,A	MQ3799	
MR322	1N3491	
MR323	1N3491	
MR324	1N3491	
MR325	1N3491	
MR326	1N3491	
MR327	1N3491	
MR328	1N3491	
MR330	1N3491	
MR331	1N3491	
MR810	MR322	
MR811	MR322	
MR812	MR322	

DEVICE	REFERENCE	SUPP.
MR814	MR322	
MR816	MR322	
MR830	1N4933	
MR831	1N4933	
MR832	1N4933	
MR833	1N4933	
MR834	1N4933	
MR835	1N4933	
MR836	1N4933	
MR840	MR322	
MR841	MR322	
MR842	MR322	
MR844	MR322	
MR846	MR322	
MR880	MR322	
MR881	MR322	
MR882	MR322	
MR884	MR322	
MR886	MR322	
MR890	MR322	
MR891	MR322	
MR892	MR322	
MR894	MR322	
MR896	MR322	
MR990A	MR990A	
MR991A	MR990A	
MR992A	MR990A	
MR993A	MR990A	
MR994A	MR990A	
MR995A	MR990A	
MR996A	MR990A	
MR1030	1N4719	
MR1031	1N4719	
MR1032	1N4719	
MR1033	1N4719	
MR1034	1N4719	
MR1035	1N4719	
MR1036	1N4719	
MR1038	1N4719	
MR1040	1N4719	
MR1120	MR1120	
MR1121	MR1120	
MR1122	MR1120	
MR1123	MR1120	
MR1124	MR1120	
MR1125	MR1120	
MR1126	MR1120	
MR1128	MR1120	
MR1130	MR1120	
MR1200	MR1200	
MR1201	MR1200	
MR1202	MR1200	
MR1203	MR1200	
MR1205	MR1200	
MR1207	MR1200	
MR1208	MR1200	
MR1209	MR1200	
MR1210	MR1210	1
MR1211	MR1210	1
MR1212	MR1210	1
MR1213	MR1210	1
MR1214	MR1210	1
MR1215	MR1210	1
MR1216	MR1210	1
MR1217	MR1210	1
MR1218	MR1210	1
MR1219	MR1210	1
MR1220	MR1220	
MR1221	MR1220	
MR1222	MR1220	
MR1223	MR1220	
MR1225	MR1220	
MR1227	MR1220	
MR1228	MR1220	
MR1229	MR1220	
MR1230	MR1230	
MR1231	MR1230	

DEVICE	REFERENCE	SUPP.
MR1232	MR1230	
MR1233	MR1230	
MR1235	MR1230	
MR1237	MR1230	
MR1238	MR1230	
MR1239	MR1230	
MR1240	MR1240	
MR1241	MR1240	
MR1242	MR1240	
MR1243	MR1240	
MR1245	MR1240	
MR1247	MR1240	
MR1248	MR1240	
MR1249	MR1240	
MR1260	MR1260	
MR1261	MR1260	
MR1262	MR1260	
MR1263	MR1260	
MR1265	MR1260	
MR1267	MR1260	
MR1268	MR1260	
MR1269	MR1260	
MR1290	MR1290	
MR1291	MR1290	
MR1292	MR1290	
MR1293	MR1290	
MR1295	MR1290	
MR1297	MR1290	
MR1298	MR1290	
MR1299	MR1290	
MR1337	MR1337	
MR1366	1N4933	
MR1376	1N4933	
MR1386	1N4933	
MR1396	1N4933	
MR1810	MR1210	1
MR1811	MR1210	1
MR1812	MR1210	1
MR1813	MR1210	1
MR1814	MR1210	1
MR1815	MR1210	1
MR1816	MR1210	1
MR1817	MR1210	1
MR1818	MR1210	1
MR1819	MR1210	1
MR2080HA	MR2080HA	
MR2081HA	MR2080HA	
MR2082HA	MR2080HA	
MR2083HA	MR2080HA	
MR2084HA	MR2080HA	
MR2100HA	MR2100HA	
MR2101HA	MR2100HA	
MR2102HA	MR2100HA	
MR2103HA	MR2100HA	
MR2104HA	MR2100HA	
MR2266	MR2266	
MR2271	MR2271	
MR2272	MR2272	
MR2273	MR2266	
MRA130	MRA130	
MRA131	MRA130	
MRA132	MRA130	
MRA133	MRA130	
MRA134	MRA130	
MRA160	MRA160	
MRA161	MRA160	
MRA162	MRA160	
MRA163	MRA160	
MRA164	MRA160	
MRA330	MRA330	
MRA331	MRA330	
MRA332	MRA330	
MRA333	MRA330	
MRA334	MRA330	
MRA360	MRA360	
MRA361	MRA360	
MRA362	MRA360	

DEVICE	REFERENCE	SUPP.
MRA363	MRA360	
MRA364	MRA360	
MRD100	MRD100	
MRD150	MRD100	
MRD200	MRD200	
MRD210	MRD210	
MRD250	MRD250	
MRD300	MRD300	
MRD310	MRD310	
MRD450	MRD450	
MRD500	MRD500	2
MRD501	MRD500	2
MRD600	MRD600	
MSD6100	MSD6100	
MSD6101	MSD6101	
MSD6102	MSD6102	
MSD6150	MSD6150	2
MU4891	MU4891	
MU4892	MU4891	
MU4893	MU4891	
MU4894	MU4891	
MV830	MV830	
MV831	MV830	
MV832	MV830	
MV833	MV830	
MV834	MV830	
MV835	MV830	
MV836	MV830	
MV837	MV830	
MV838	MV830	
MV839	MV830	
MV840	MV830	
MV1401	MV1401	2
MV1403	MV1401	2
MV1404	MV1401	2
MV1405	MV1401	2
MV1620	MV1620	
MV1622	MV1620	
MV1624	MV1620	
MV1626	MV1620	
MV1628	MV1620	
MV1630	MV1620	
MV1632	MV1620	
MV1634	MV1620	
MV1636	MV1620	
MV1638	MV1620	
MV1640	MV1620	
MV1642	MV1620	
MV1644	MV1620	
MV1646	MV1620	
MV1648	MV1620	
MV1650	MV1620	
MV1652	MV1652	
MV1654	MV1652	
MV1656	MV1652	
MV1658	MV1652	
MV1660	MV1652	
MV1662	MV1652	
MV1664	MV1652	
MV1666	MV1652	
MV1804	1N4387	
MV1805C	MV1805C	
MV1806	1N4388	
MV1806C	1N5149	
MV1807C	1N5149	
MV1807C1	1N5150A	
MV1808A,B,C	1N5151	
MV1808B1,C1	1N5150A	
MV1809C,C1	MV1809C	
MV1810A,B	1N5154	
MV1810B1	1N5150A	
MV1812A,B	1N5156	
MV1816A,B	MV1816A	
MV1816A1,B1	MV1816A	
MV1817A,B	MV1817A	
MV1817A1,B1	MV1817A	
MV1858D	MV1858D	

DEVICE	REFERENCE	SUPP.
MV1860D	MV1858D	
MV1862D	MV1858D	
MV1863D	MV1858D	
MV1864D	MV1858D	
MV1865D	MV1858D	
MV1866D	MV1858D	
MV1868D	MV1858D	
MV1870D	MV1858D	
MV2101	MV2101	
MV2102	MV2101	
MV2103	MV2101	
MV2104	MV2101	
MV2105	MV2101	
MV2106	MV2101	
MV2107	MV2101	
MV2108	MV2101	
MV2109	MV2101	
MV2110	MV2101	
MV2111	MV2101	
MV2112	MV2101	
MV2113	MV2101	
MV2114	MV2101	
MV2115	MV2101	
MV2201	MV2201	1
MV2203	MV2201	1
MV2205	MV2201	1
MV2209	MV2201	1
MZ92-2.4	MZ92-2.4	2
MZ92-2.5	MZ92-2.4	2
MZ92-2.7	MZ92-2.4	2
MZ92-2.8	MZ92-2.4	2
MZ92-3.0	MZ92-2.4	2
MZ92-3.3	MZ92-2.4	2
MZ92-3.6	MZ92-2.4	2
MZ92-3.9	MZ92-2.4	2
MZ92-4.3	MZ92-2.4	2
MZ92-4.7	MZ92-2.4	2
MZ92-5.1	MZ92-2.4	2
MZ92-5.6	MZ92-2.4	2
MZ92-6.0	MZ92-2.4	2
MZ92-6.2	MZ92-2.4	2
MZ92-6.8	MZ92-2.4	2
MZ92-7.5	MZ92-2.4	2
MZ92-8.2	MZ92-2.4	2
MZ92-8.7	MZ92-2.4	2
MZ92-9.1	MZ92-2.4	2
MZ92-10	MZ92-2.4	2
MZ92-11	MZ92-2.4	2
MZ92-12	MZ92-2.4	2
MZ92-13	MZ92-2.4	2
MZ92-14	MZ92-2.4	2
MZ92-15	MZ92-2.4	2
MZ92-16	MZ92-2.4	2
MZ92-17	MZ92-2.4	2
MZ92-18	MZ92-2.4	2
MZ92-19	MZ92-2.4	2
MZ92-20	MZ92-2.4	2
MZ92-22	MZ92-2.4	2
MZ92-24	MZ92-2.4	2
MZ92-25	MZ92-2.4	2
MZ92-27	MZ92-2.4	2
MZ92-28	MZ92-2.4	2
MZ92-30	MZ92-2.4	2
MZ92-33	MZ92-2.4	2
MZ92-36	MZ92-2.4	2
MZ92-39	MZ92-2.4	2
MZ92-43	MZ92-2.4	2
MZ92-47	MZ92-2.4	2
MZ92-51	MZ92-2.4	2
MZ92-56	MZ92-2.4	2
MZ92-60	MZ92-2.4	2
MZ92-62	MZ92-2.4	2
MZ92-68	MZ92-2.4	2
MZ92-75	MZ92-2.4	2
MZ92-82	MZ92-2.4	2
MZ92-87	MZ92-2.4	2
MZ92-91	MZ92-2.4	2

DEVICE	REFERENCE	SUPP.
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MZ92-110	MZ92-2.4	2
MZ92-120	MZ92-2.4	2
MZ92-130	MZ92-2.4	2
MZ92-140	MZ92-2.4	2
MZ92-150	MZ92-2.4	2
MZ92-160	MZ92-2.4	2
MZ92-170	MZ92-2.4	2
MZ92-180	MZ92-2.4	2
MZ92-190	MZ92-2.4	2
MZ92-200	MZ92-2.4	2
MZ500	MZ500	
MZ605	MZ600	
MZ610	MZ600	
MZ620	MZ600	
MZ640	MZ600	
MZ805	MZ600	
MZ810	MZ600	
MZ820	MZ600	
MZ840	MZ600	
MZ1000	MZ1000	
MZ4614	1N4099	
MZ4615	1N4099	
MZ4616	1N4099	
MZ4617	1N4099	
MZ4618	1N4099	
MZ4619	1N4099	
MZ4620	1N4099	
MZ4621	1N4099	
MZ4622	1N4099	
MZ4623	1N4099	
MZ4624	1N4099	
MZ4625	1N4099	
MZ4626	1N4099	
MZ4627	1N4099	
MZC1.8B10	MZC2.4A10	2
MZC2.0B10	MZC2.4A10	2
MZC2.2B10	MZC2.4A10	2
MZC2.4B10	MZC2.4A10	2
MZC2.7B10	MZC2.4A10	2
MZC3.0B10	MZC2.4A10	2
MZC3.3B10	MZC2.4A10	2
MZC3.6B10	MZC2.4A10	2
MZC3.9B10	MZC2.4A10	2
MZC4.3B10	MZC2.4A10	2
MZC4.7B10	MZC2.4A10	2
MZC5.1B10	MZC2.4A10	2
MZC5.6B10	MZC2.4A10	2
MZC6.2B10	MZC2.4A10	2
MZC6.8B10	MZC2.4A10	2
MZC7.5B10	MZC2.4A10	2
MZC8.2B10	MZC2.4A10	2
MZC8.7B10	MZC2.4A10	2
MZC9.1B10	MZC2.4A10	2
MZC10B10	MZC2.4A10	2
MZC11B10	MZC2.4A10	2
MZC12B10	MZC2.4A10	2
MZC13B10	MZC2.4A10	2
MZC14B10	MZC2.4A10	2
MZC15B10	MZC2.4A10	2
MZC16B10	MZC2.4A10	2
MZC17B10	MZC2.4A10	2
MZC18B10	MZC2.4A10	2
MZC19B10	MZC2.4A10	2
MZC20B10	MZC2.4A10	2
MZC22B10	MZC2.4A10	2
MZC24B10	MZC2.4A10	2
MZC25B10	MZC2.4A10	2
MZC27B10	MZC2.4A10	2
MZC28B10	MZC2.4A10	2
MZC30B10	MZC2.4A10	2
MZC33B10	MZC2.4A10	2
MZC36B10	MZC2.4A10	2
MZC39B10	MZC2.4A10	2
MZC43B10	MZC2.4A10	2
MZC47B10	MZC2.4A10	2

DEVICE	REFERENCE	SUPP.
MZC51B10	MZC2.4A10	2
MZC56B10	MZC2.4A10	2
MZC60B10	MZC2.4A10	2
MZC62B10	MZC2.4A10	2
MZC68B10	MZC2.4A10	2
MZC75B10	MZC2.4A10	2
MZC82B10	MZC2.4A10	2
MZC87B10	MZC2.4A10	2
MZC91B10	MZC2.4A10	2
MZC100B10	MZC2.4A10	2
MZC110B10	MZC2.4A10	2
MZC120B10	MZC2.4A10	2
MZC130B10	MZC2.4A10	2
MZC140B10	MZC2.4A10	2
MZC150B10	MZC2.4A10	2
MZC160B10	MZC2.4A10	2
MZC170B10	MZC2.4A10	2
MZC180B10	MZC2.4A10	2
MZC190B10	MZC2.4A10	2
MZC200B10	MZC2.4A10	2
MZC2.4A10	MZC2.4A10	2
MZC2.5A10	MZC2.4A10	2
MZC2.7A10	MZC2.4A10	2
MZC2.8A10	MZC2.4A10	2
MZC3.0A10	MZC2.4A10	2
MZC3.3A10	MZC2.4A10	2
MZC3.6A10	MZC2.4A10	2
MZC3.9A10	MZC2.4A10	2
MZC4.3A10	MZC2.4A10	2
MZC4.7A10	MZC2.4A10	2
MZC5.1A10	MZC2.4A10	2
MZC5.6A10	MZC2.4A10	2
MZC6.0A10	MZC2.4A10	2
MZC6.2A10	MZC2.4A10	2
MZC6.8A10	MZC2.4A10	2
MZC7.5A10	MZC2.4A10	2
MZC8.2A10	MZC2.4A10	2
MZC8.7A10	MZC2.4A10	2
MZC9.1A10	MZC2.4A10	2
MZC10A10	MZC2.4A10	2
MZC11A10	MZC2.4A10	2
MZC12A10	MZC2.4A10	2
MZC13A10	MZC2.4A10	2
MZC14A10	MZC2.4A10	2
MZC15A10	MZC2.4A10	2
MZC16A10	MZC2.4A10	2
MZC17A10	MZC2.4A10	2
MZC18A10	MZC2.4A10	2
MZC19A10	MZC2.4A10	2
MZC20A10	MZC2.4A10	2
MZC22A10	MZC2.4A10	2
MZC24A10	MZC2.4A10	2
MZC25A10	MZC2.4A10	2
MZC27A10	MZC2.4A10	2
MZC28A10	MZC2.4A10	2
MZC30A10	MZC2.4A10	2
MZC33A10	MZC2.4A10	2
MZC36A10	MZC2.4A10	2
MZC39A10	MZC2.4A10	2
MZC43A10	MZC2.4A10	2
MZC47A10	MZC2.4A10	2
MZC51A10	MZC2.4A10	2
MZC56A10	MZC2.4A10	2
MZC60A10	MZC2.4A10	2
MZC62A10	MZC2.4A10	2
MZC68A10	MZC2.4A10	2
MZC75A10	MZC2.4A10	2
MZC82A10	MZC2.4A10	2
MZC87A10	MZC2.4A10	2
MZC91A10	MZC2.4A10	2
MZC100A10	MZC2.4A10	2
MZC110A10	MZC2.4A10	2
MZC120A10	MZC2.4A10	2
MZC130A10	MZC2.4A10	2
MZC140A10	MZC2.4A10	2
MZC150A10	MZC2.4A10	2
MZC160A10	MZC2.4A10	2
MZC170A10	MZC2.4A10	2
MZC180A10	MZC2.4A10	2
MZC190A10	MZC2.4A10	2
MZC200A10	MZC2.4A10	2
M4L3052	1N5158	
M4L3053	1N5158	
M4L3054	1N5158	
M4L3055	1N5158	
M4L3056	1N5158	

2N... JEDEC REGISTERED DEVICE SPECIFICATIONS

TRANSISTORS

- **Amplifier**
- **Chopper**
- **Light Sensitive**
- **Multiple Device**
- **Power**
- **Switching**

2N2857 (SILICON)

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

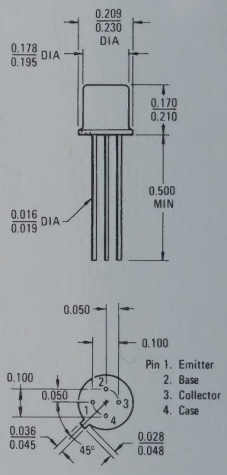
- High Current-Gain—Bandwidth Product —
  f_T = 1.6 GHz (Typ) @ I_C = 8.0 mAdc
- Low Noise Figure —
  NF = 4.5 dB (Max) @ f = 450 MHz
- Low Collector-Base Time Constant —
  $r_b'C_c$ = 15 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Ideal for Micro-Power Applications

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current — Continuous	I_C	40	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 20 (10)
TO-72 PACKAGE

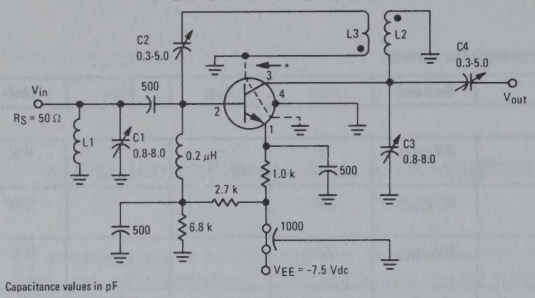
Active Elements Isolated from Case

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage** (I_C = 3.0 mAdc, I_B = 0)	BV_{CEO}	15	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	2.5	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30	–	150	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	1000	–	1900	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	–	0.7	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	50	–	220	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b'C_c$	4.0	–	15	ps
Noise Figure (Figure 1)	NF				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, R_S = 50 ohms, f = 450 MHz) ②		–	5.8	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 450 MHz)		–	3.7	4.5	
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (Figure 1)	G_{pe}				dB
(I_E = 0.1 mAdc, V_{CE} = 1.0 Vdc, f = 450 MHz) ②		–	11	–	
(I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, f = 450 MHz)		12.5	–	19	
Power Output (Figure 2) (I_E = 12 mAdc, V_{CB} = 10 Vdc, f = 500 MHz)	P_{out}	30	–	–	mW

*Indicates JEDEC Registered Data.
**Motorola guarantees this data in addition to JEDEC Registered Data.
① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.
② Micro-Power Specifications.

FIGURE 1 – TEST CIRCUIT FOR NOISE FIGURE AND POWER GAIN



L1, L2 – Silver-plated brass rod, 1-1/2" long and 1/4" dia. Install at least 1/2" from nearest vertical chassis surface.

L3 – 1/2 turn #16 AWG wire, located 1/4" from and parallel to L2.

* – External interlead shield to isolate collector lead from emitter and base leads.

Neutralization Procedure:

(A) Connect 450-MHz signal generator (with RS = 50 ohms) to input terminals of amplifier.

(B) Connect 50-ohm RF voltmeter across output terminals of amplifier.

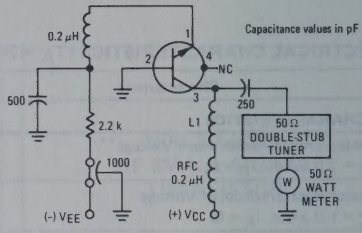
(C) Apply VEE, and with signal generator adjusted for 5 mV output from amplifier, tune C1, C3, and C4 for maximum output.

(D) Interchange connections to signal generator and RF voltmeter.

(E) With sufficient signal applied to output terminals of amplifier, adjust C2 for minimum indication at input.

(F) Repeat steps (A), (B), and (C) to determine if retuning is necessary.

FIGURE 2 – TEST CIRCUIT FOR OSCILLATOR POWER OUTPUT



L1 – 3 turns #16 AWG wire, 3/8" O.D. 1-1/4" long.

FIGURE 3 – NOISE FIGURE versus FREQUENCY

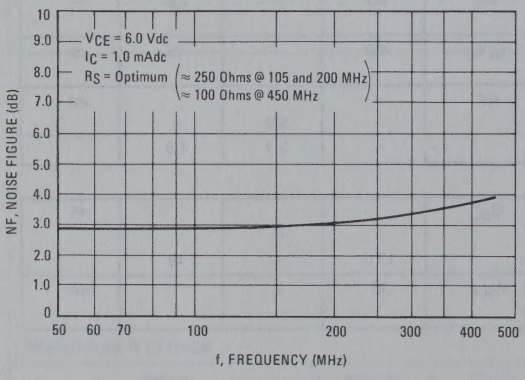


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

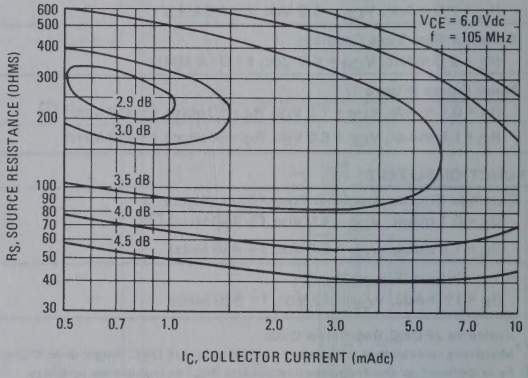


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

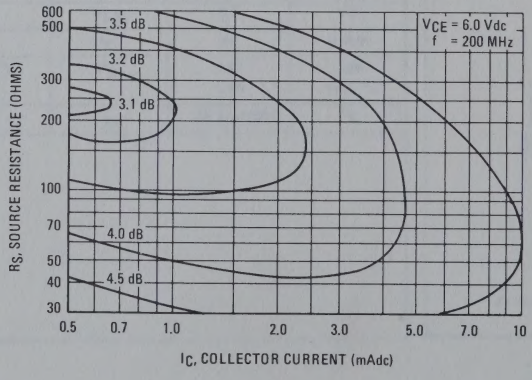


FIGURE 6 – CURRENT-GAIN–BANDWIDTH PRODUCT

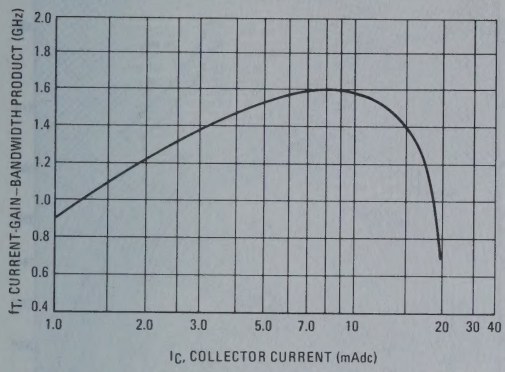


FIGURE 7 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

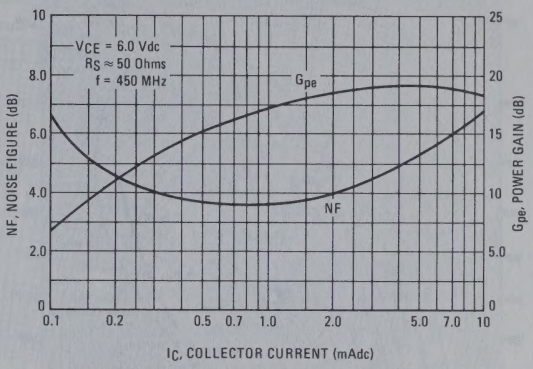


FIGURE 8 – INPUT ADMITTANCE versus FREQUENCY

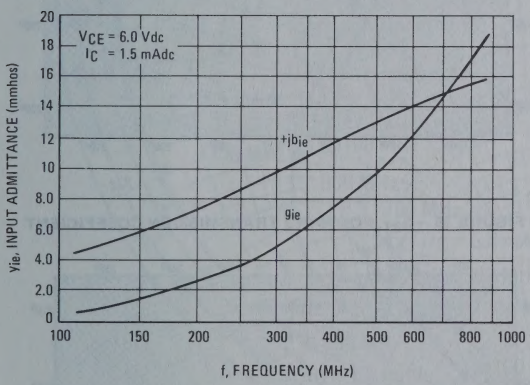


FIGURE 9 – OUTPUT ADMITTANCE versus FREQUENCY

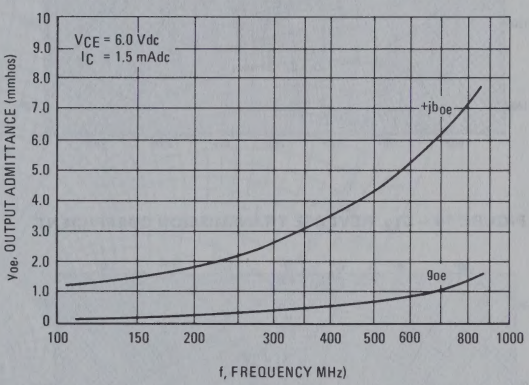


FIGURE 10 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

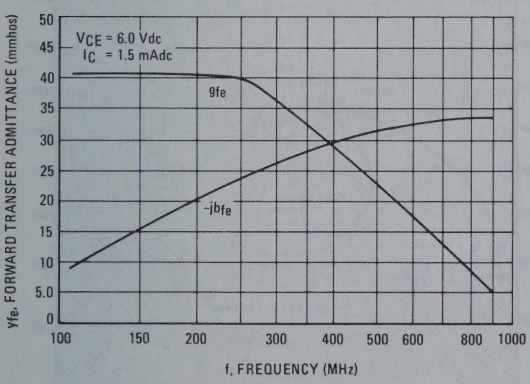


FIGURE 11 –REVERSE TRANSFER ADMITTANCE versus FREQUENCY

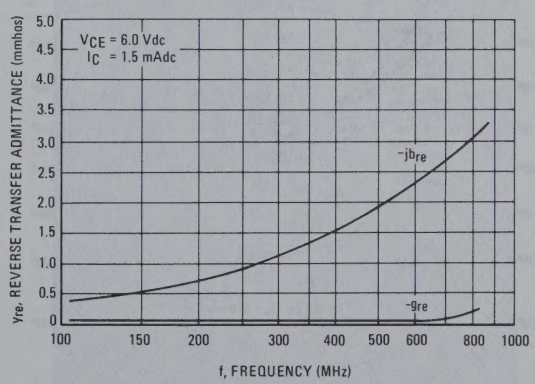


FIGURE 12 – S_{11}, INPUT REFLECTION COEFFICIENT

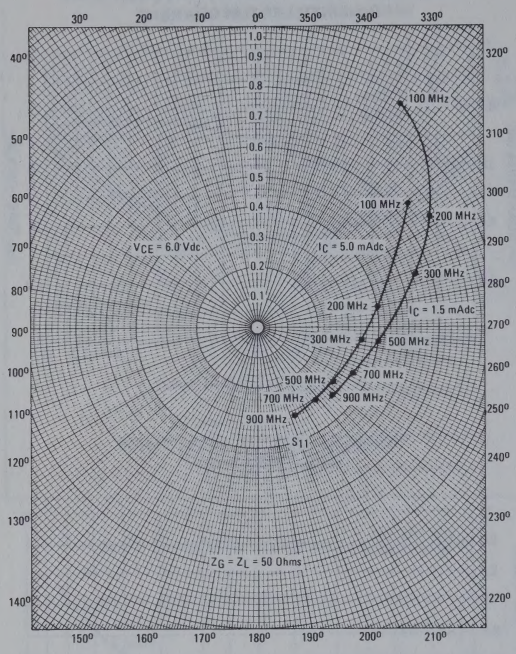


FIGURE 13 – S_{22}, OUTPUT REFLECTION COEFFICIENT

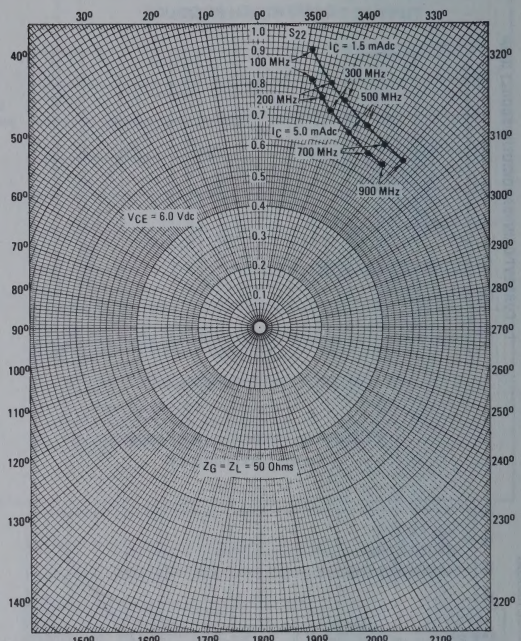


FIGURE 14 – S_{12}, REVERSE TRANSMISSION COEFFICIENT

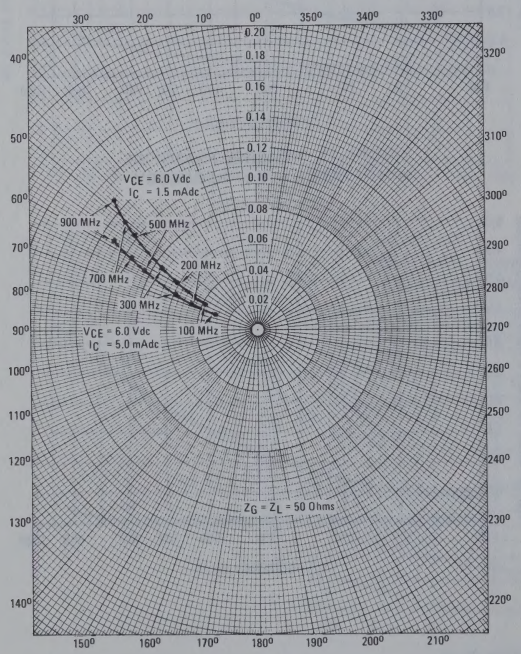


FIGURE 15 – S_{21}, FORWARD TRANSMISSION COEFFICIENT

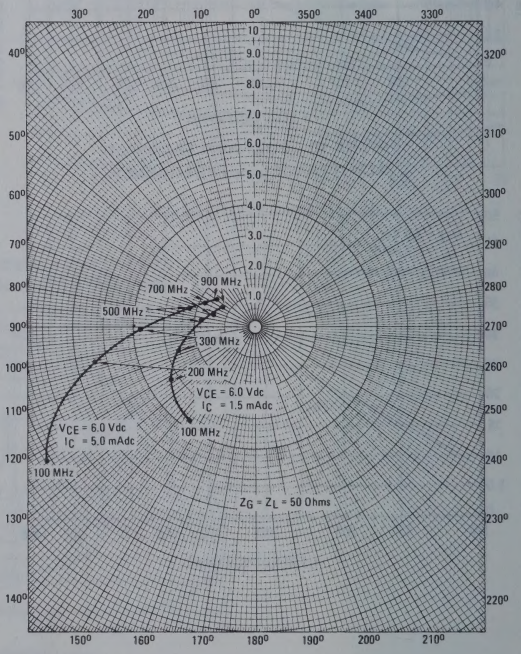
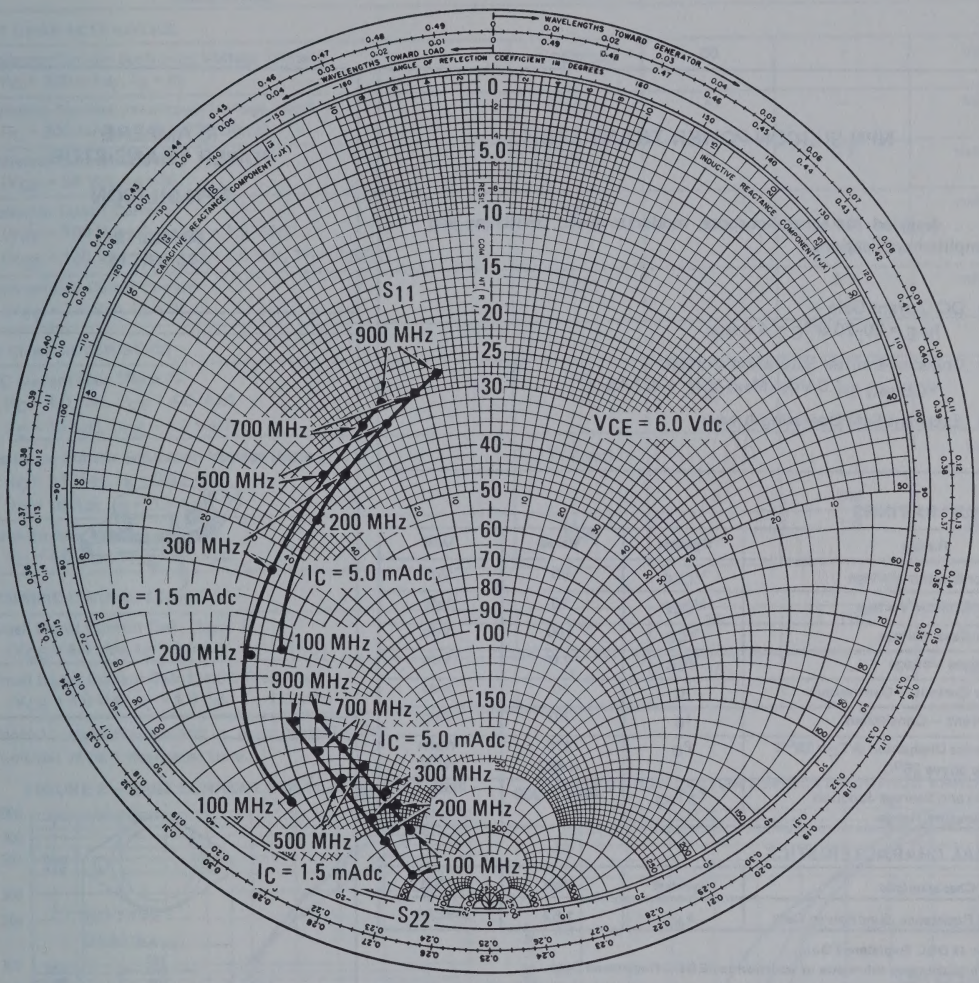


FIGURE 16 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



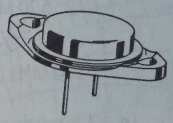
2N3055 (SILICON)

NPN SILICON POWER TRANSISTOR

. . . designed for general-purpose, moderate speed, switching and amplifier applications.

- DC Current Gain –
  h_{FE} = 20–70 @ I_C = 4.0 Adc
- Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 1.0 Vdc (Max) @ I_C = 4.0 Adc
- Excellent Safe Operating Area

15 AMPERE
POWER TRANSISTOR
NPN SILICON
60 VOLTS
115 WATTS



*MAXIMUM RATINGS

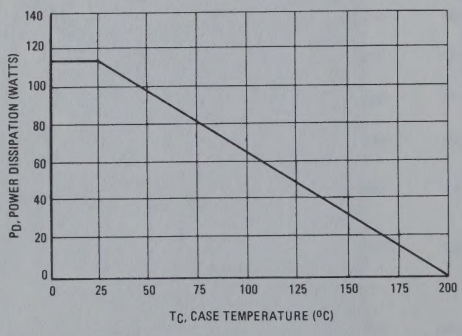
Rating	Symbol	Value	Unit
#Collector-Emitter Voltage	V_{CEO}	60	Vdc
Collector-Emitter Voltage	V_{CER}	70	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	7.0	Vdc
Collector Current – Continuous	I_C	15	Adc
Base Current – Continuous	I_B	7.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	115 0.657	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

THERMAL CHARACTERISTICS

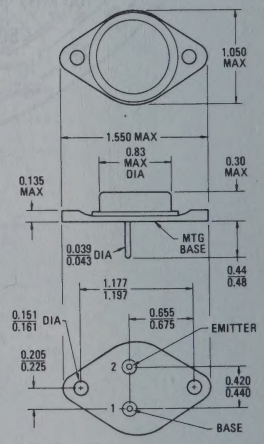
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.52	°C/W

*Indicates JEDEC Registered Data.
#Motorola guarantees this value in addition to JEDEC Registered Data.

FIGURE 1 – POWER TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 9. Both limits are applicable and must be observed.



CASE 11
(TO-3)

Collector Connected to Case

***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, R_{BE} = 100 Ohms)	BV_{CER}	70	–	Vdc
Collector-Emitter Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	0.7	mAdc
Collector Cutoff Current (V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc) (V_{CE} = 100 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	I_{CEX}	– –	5.0 30	mAdc
Emitter-Base Cutoff Current (V_{EB} = 7.0 Vdc, I_C = 0)	I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (Note 1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc) (I_C = 10 Adc, V_{CE} = 4.0 Vdc)	h_{FE}	20 5.0	70 –	–
Collector-Emitter Saturation Voltage (Note 1) (I_C = 4.0 Adc, I_B = 0.4 Adc) (I_C = 10 Adc, I_B = 3.3 Adc)	$V_{CE(sat)}$	– –	1.1 8.0	Vdc
Base-Emitter Voltage (Note 1) (I_C = 4.0 Adc, V_{CE} = 4.0 Vdc)	V_{BE}	–	1.8	Vdc
DYNAMIC CHARACTERISTICS				
Small Signal Current Gain (Note 1) (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1.0 kHz)	h_{fe}	15	120	–
Small Signal Current Gain Cutoff Frequency (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1.0 kHz)	$f_{\alpha e}$	10	–	kHz

Note 1: Pulse Width ≈ 300 μs, Duty Cycle ≤ 2.0%.

*Indicates JEDEC Registered Data.

FIGURE 2 – BASE CURRENT-VOLTAGE VARIATIONS

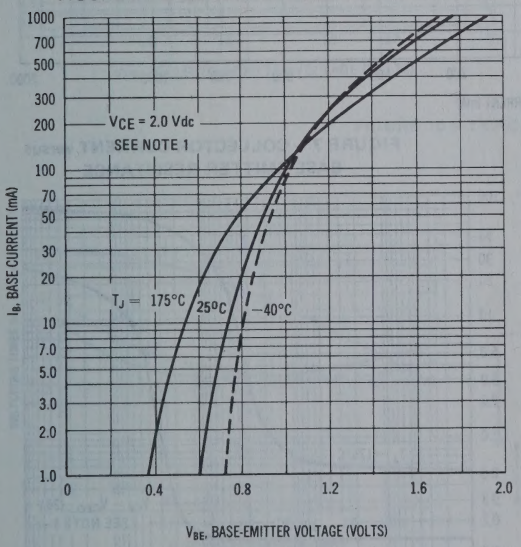
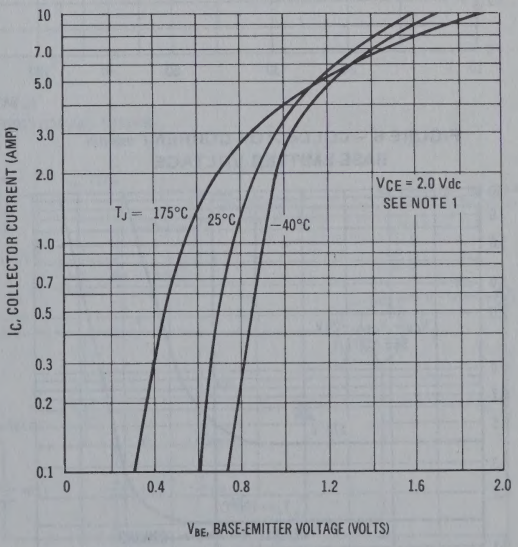


FIGURE 3 – COLLECTOR CURRENT-VOLTAGE VARIATIONS



Note 1. Pulse Test: Pulse Width ≈ 200 μs, Duty Cycle ≈ 1.5%.

FIGURE 4 – COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

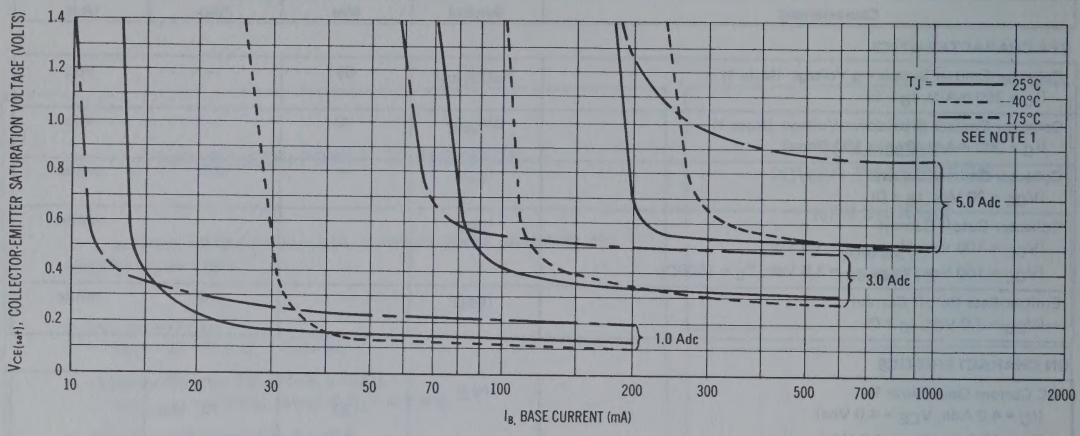


FIGURE 5 – BASE-EMITTER SATURATION VOLTAGE VARIATIONS

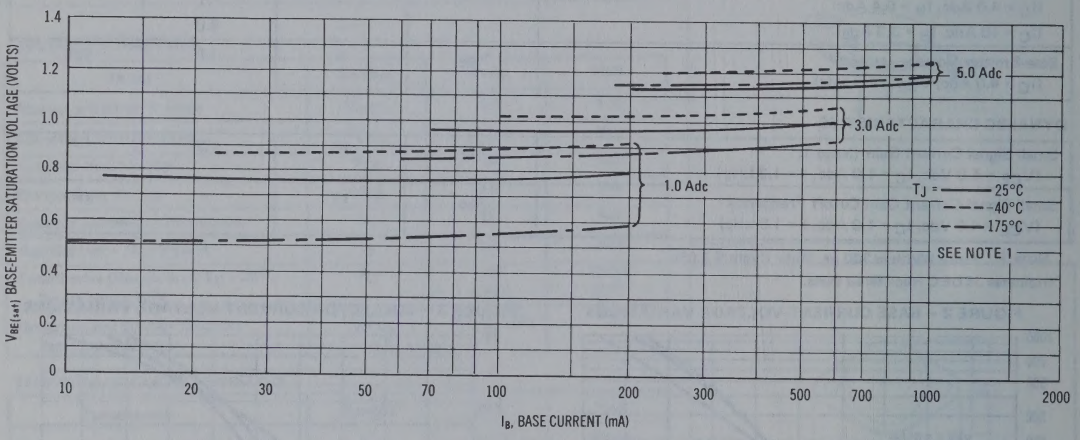


FIGURE 6 – COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

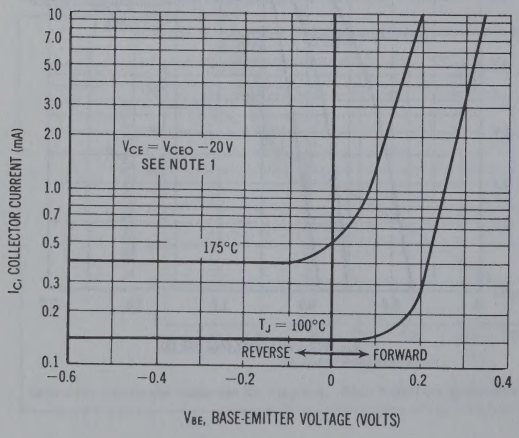


FIGURE 7 – COLLECTOR CURRENT versus BASE-EMITTER RESISTANCE

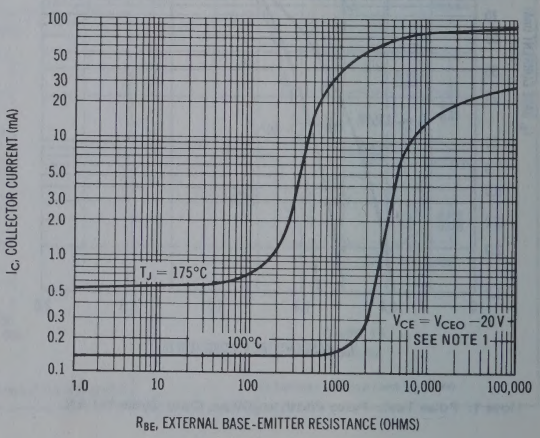


FIGURE 8 – CURRENT GAIN VARIATIONS

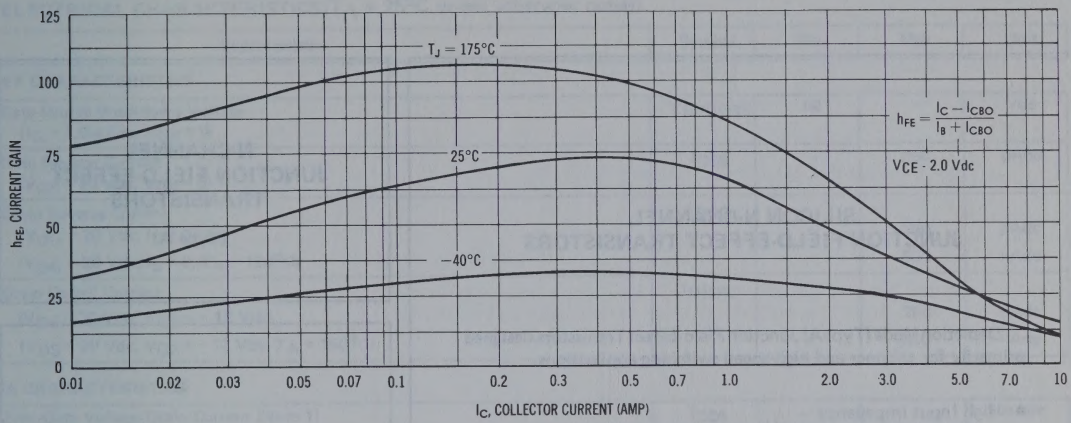
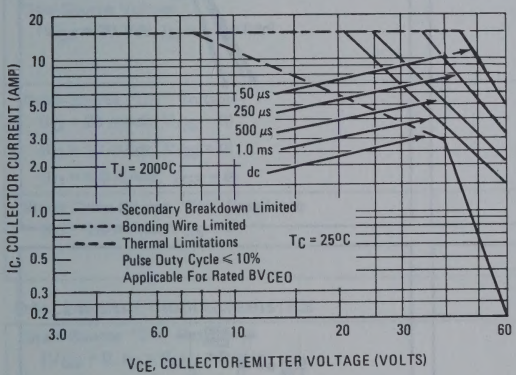
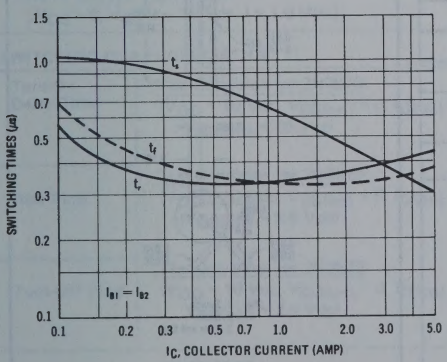


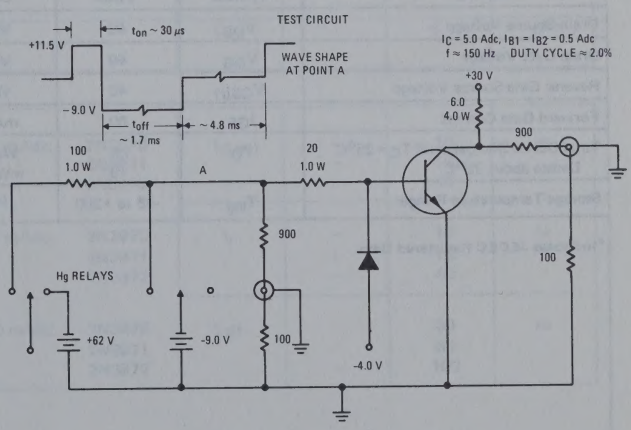
FIGURE 9 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 10 – TYPICAL SWITCHING TIMES





2N3970 (SILICON)
2N3971
2N3972

SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- High Input Impedance –
  I_{GSS} = 250 pAdc (Max) @ V_{GS} = 20 Vdc
- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 30 Ohms (Max) @ f = 1.0 kHz (2N3970)
- Guaranteed Switching Characteristics

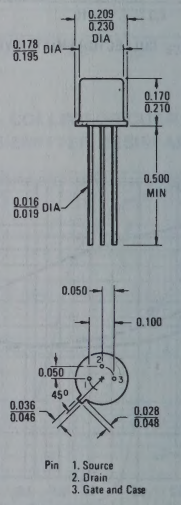
N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	40	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.8 10	Watts mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



Pin 1. Source
2. Drain
3. Gate and Case

CASE 22 (4)
TO-18

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{GS} = 0)		$V_{(BR)GSS}$	40	–	Vdc
Gate Reverse Current (V_{GS} = 20 Vdc, V_{DS} = 0)		I_{GSS}	–	250	pAdc
Drain Reverse Current		I_{DGO}			
(V_{DG} = 20 Vdc, I_S = 0)			–	250	pAdc
(V_{DG} = 20 Vdc, I_S = 0, T_A = 150°C)			–	500	nAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 20 Vdc, V_{GS} = – 12 Vdc)			–	250	pAdc
(V_{DS} = 20 Vdc, V_{GS} = – 12 Vdc, T_A = 150°C)			–	500	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = 20 Vdc, V_{GS} = 0)	2N3970	I_{DSS}	50	150	mAdc
	2N3971		25	75	
	2N3972		5.0	30	
Gate-Source Voltage (V_{DS} = 20 Vdc, I_D = 1.0 nAdc)		V_{GS}			Vdc
	2N3970		4.0	10	
	2N3971		2.0	5.0	
	2N3972		0.5	3.0	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 20 mAdc, V_{GS} = 0)	2N3970		–	1.0	
(I_D = 10 mAdc, V_{GS} = 0)	2N3971		–	1.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N3972		–	2.0	
Static Drain-Source "ON" Resistance (I_D = 1.0 mAdc, V_{GS} = 0)		$r_{DS(on)}$			Ohms
	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)		$r_{ds(on)}$			Ohms
	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	
Input Capacitance (V_{DS} = 20 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	25	pF
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = – 12 Vdc, f = 1.0 MHz)		C_{rss}	–	6.0	pF
SWITCHING CHARACTERISTICS					
Turn-On Delay Time	Test Condition for 2N3970: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 20 mAdc, $V_{GS(off)}$ = 10 Vdc)	$t_{d(on)}$			ns
	2N3970		–	10	
	2N3971		–	15	
	2N3972		–	40	
Rise Time	Test Condition for 2N3971: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 10 mAdc, $V_{GS(off)}$ = 5.0 Vdc)	t_r			ns
	2N3970		–	10	
	2N3971		–	15	
	2N3972		–	40	
Turn-Off Time	Test Condition for 2N3972: (V_{DD} = 10 Vdc, $V_{GS(on)}$ = 0, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(off)}$ = 3.0 Vdc)	t_{off}			ns
	2N3970		–	30	
	2N3971		–	60	
	2N3972		–	100	

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle = 3.0%.

2N3993, 2N3994 (SILICON)
2N3994A

SILICON P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for chopper and high-speed switching applications.

- Low Leakage Current –
  I_{DGO} = 1.2 nAdc (Max) @ V_{DG} = 15 Vdc
- Low Reverse Transfer Capacitance –
  C_{rss} = 4.5 pF (Max) @ V_{GS} = 10 Vdc (2N3993)
- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 150 Ohms (Max) @ f = 1.0 kHz (2N3993)

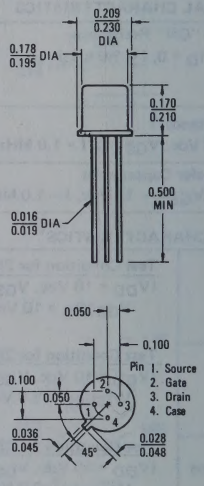
P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

(Type A)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



TO-72
CASE 20 (5)

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	Vdc
Drain Reverse Current		I_{DGO}			
(V_{DG} = –15 Vdc, I_S = 0)			–	1.2	nAdc
(V_{DG} = –15 Vdc, I_S = 0, T_A = 150°C)			–	1.2	μAdc
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = –10 Vdc, V_{GS} = 10 Vdc)	2N3993		–	1.2	nAdc
(V_{DS} = –10 Vdc, V_{GS} = 6.0 Vdc)	2N3994, 2N3994A		–	1.2	
(V_{DS} = –10 Vdc, V_{GS} = 10 Vdc, T_A = 150°)	2N3993		–	1.0	μAdc
(V_{DS} = –10 Vdc, V_{GS} = 6.0 Vdc, T_A = 150°)	2N3994, 2N3994A		–	1.0	
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1)		I_{DSS}			mAdc
(V_{DS} = –10 Vdc, V_{GS} = 0)	2N3993		10		
	2N3994, 2N3994A		2.0	–	
Gate-Source Voltage		V_{GS}			Vdc
(V_{DS} = –10 Vdc, I_D = –1.0 μAdc)	2N3993		4.0	9.5	
	2N3994, 2N3994A		1.0	5.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance		$r_{ds(on)}$			Ohms
(V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N3993		–	150	
	2N3994, 2N3994A		–	300	
Forward Transadmittance (Note 1)		$\|Y_{fs}\|$			mmhos
(V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N3993		6.0	12	
	2N3994		4.0	10	
	2N3994A		5.0	10	
Input Capacitance		C_{iss}			pF
(V_{DS} = –10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N3993, 2N3994		–	16	
	2N3994A		–	12	
Reverse Transfer Capacitance		C_{rss}			pF
(V_{DS} = 0, V_{GS} = 10 Vdc, f = 1.0 MHz)	2N3993		–	4.5	
(V_{DS} = 0, V_{GS} = 6.0 Vdc, f = 1.0 MHz)	2N3994		–	5.0	
	2N3994A		–	3.5	

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse With = 100 ms, Duty Cycle ≤ 10%

2N4342 (SILICON)
2N4343

SILICON P-CHANNEL
JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for high-gain audio frequency applications.

- High Forward Transadmittance —
  $|Y_{fs}|$ = 4.0 mmhos (Min) @ V_{DS} = -10 Vdc (2N4343)
- Low Noise Figure —
  NF = 1.5 dB (Max) @ f = 100 Hz
- Low Drain-Source "ON" Resistance —
  $r_{ds(on)}$ = 350 Ohms (Max) @ f = 1.0 kHz (2N4343)

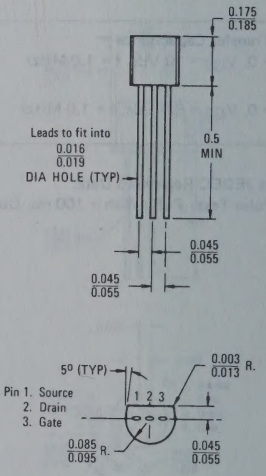
P-CHANNEL
JUNCTION FIELD-EFFECT
TRANSISTORS

(Type A)

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	$V_{GS(r)}$	25	Vdc
Forward Gate Current	I_{GF}	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	°C

*Indicates JEDEC Registered Data.



CASE 29 (7)
TO-92

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	25	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = -10 Vdc, I_D = 1.0 μAdc)	2N4342 2N4343	$V_{GS(off)}$	1.0 2.0	5.5 10	Vdc
Gate Reverse Current (V_{GS} = 15 Vdc, V_{DS} = 0) (V_{GS} = 15 Vdc, V_{DS} = 0, T_A = 65°C)		I_{GSS}	– –	10 0.5	nAdc μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (V_{DS} = -10 Vdc, V_{GS} = 0)	2N4342 2N4343	I_{DSS}	4.0 10	12 30	mAdc
Gate-Source Voltage (V_{DS} = -10 Vdc, I_D = 0.4 mAdc) (V_{DS} = -10 Vdc, I_D = 1.0 mAdc)	2N4342 2N4343	V_{GS}	0.7 1.8	5.0 9.0	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4342 2N4343	$r_{ds(on)}$	– –	700 350	Ohms
Forward Transadmittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4342 2N4343	$\lvert y_{fs} \rvert$	2000 4000	6000 8000	μmhos
Forward Transconductance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)	2N4342 2N4343	$Re(y_{fs})$	1500 3000	– –	μmhos
Output Admittance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N4342 2N4343	$\lvert y_{os} \rvert$	– –	75 100	μmhos
Input Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	20	pF
Reverse Transfer Capacitance (V_{DS} = -10 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	5.0	pF
Common-Source Noise Figure (V_{DS} = -10 Vdc, V_{GS} = 0, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz) (V_{DS} = -10 Vdc, V_{GS} = 2.0 Vdc, R_G = 1.0 Megohm, f = 100 Hz, BW = 15 Hz)	2N4342 2N4343	NF	– –	1.5 1.5	dB
Equivalent Short-Circuit Input Noise Voltage (V_{DS} = -10 Vdc, V_{GS} = 0, f = 100 Hz, BW = 15 Hz) (V_{DS} = -10 Vdc, V_{GS} = 2.0 Vdc, f = 100 Hz, BW = 15 Hz)	2N4342 2N4343	E_n	– –	0.08 0.08	$\mu V/\sqrt{Hz}$

*Indicates JEDEC Registered Data.

2N4856, A (SILICON)
thru
2N4861, A

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) symmetrical Field-Effect transistors designed for low-power switching and chopper applications.

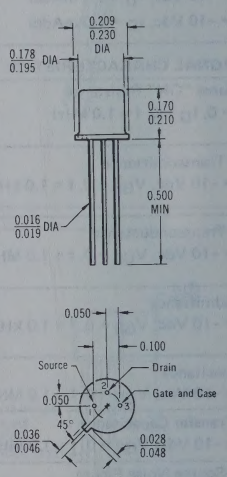
- Low Drain-Source "ON" Resistance –
  $r_{ds(on)}$ = 25 Ohms (Max) @ f = 1.0 kHz – 2N4856,A, 2N4859,A
- Low Drain Cutoff Current –
  $I_{D(off)}$ = 250 pAdc (Max) @ V_{DS} = 15 Vdc

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS
(Type A)

*MAXIMUM RATINGS

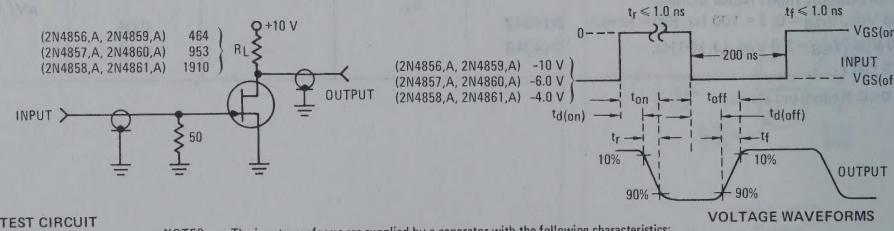
Rating	Symbol	2N4856,A 2N4857,A 2N4858,A	2N4859,A 2N4860,A 2N4861,A	Unit
Drain-Gate Voltage	V_{DG}	+40	+30	Vdc
Drain-Source Voltage	V_{DS}	+40	+30	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	-30	Vdc
Forward Gate Current	I_{GF}	50		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4		mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

*Indicates JEDEC Registered Data.



CASE 22 (4)
(TO-18)

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



NOTES: a. The input waveforms are supplied by a generator with the following characteristics:
Z_{out} = 50 ohms, Duty Cycle ≈ 2.0%.
b. Waveforms are monitored on an oscilloscope with the following characteristics:
$t_r \leq 0.75$ ns, $R_{in} \geq 1.0$ megohm, $C_{in} \leq 2.5$ pF.

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = 1.0 μAdc, V_{DS} = 0)	2N4856,A,2N4857,A,2N4858,A	$V_{(BR)GSS}$	-40	–	Vdc
	2N4859,A,2N4860,A,2N4861,A		-30	–	
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 0.5 nAdc)	2N4856,A,2N4859,A	$V_{GS(off)}$	-4.0	-10	Vdc
	2N4857,A,2N4860,A		-2.0	-6.0	
	2N4858,A,2N4861,A		-0.8	-4.0	
Gate Reverse Current		I_{GSS}			
(V_{GS} = -20 Vdc, V_{DS} = 0)	2N4856,A,2N4857,A,2N4858,A		–	0.25	nAdc
(V_{GS} = -15 Vdc, V_{DS} = 0)	2N4859,A,2N4860,A,2N4861,A		–	0.25	
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)	2N4856,A,2N4857,A,2N4858,A		–	0.5	μAdc
(V_{GS} = -15 Vdc, V_{DS} = 0, T_A = 150°C)	2N4859,A,2N4860,A,2N4861,A		–	0.5	
Drain Cutoff Current		$I_{D(off)}$			
(V_{DS} = 15 Vdc, V_{GS} = -10 Vdc)			–	0.25	nAdc
(V_{DS} = 15 Vdc, V_{GS} = -10 Vdc, T_A = 150°C)			–	0.5	μAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4856,A,2N4859,A	I_{DSS}	50	–	mAdc
	2N4857,A,2N4860,A		20	100	
	2N4858,A,2N4861,A		8.0	80	
Drain-Source "ON" Voltage		$V_{DS(on)}$			Vdc
(I_D = 20 mAdc, V_{GS} = 0)	2N4856,A,2N4859,A		–	0.75	
(I_D = 10 mAdc, V_{GS} = 0)	2N4857,A,2N4860,A		–	0.5	
(I_D = 5.0 mAdc, V_{GS} = 0)	2N4858,A,2N4861,A		–	0.5	
SMALL-SIGNAL CHARACTERISTICS					
Drain-Source "ON" Resistance (V_{GS} = 0, I_D = 0, f = 1.0 kHz)	2N4856,A,2N4859,A	$r_{ds(on)}$	–	25	Ohms
	2N4857,A,2N4860,A		–	40	
	2N4858,A,2N4861,A		–	60	
Input Capacitance (V_{DS} = 0, V_{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861	C_{iss}	–	18	pF
	2N4856 A thru 2N4861 A			10	
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = -10 Vdc, f = 1.0 MHz)	2N4856 thru 2N4861	C_{rss}	–	8.0	pF
	2N4856 A,2N4859 A		–	4.0	
	2N4857 A,2N4858 A,2N4860 A,2N4861 A		–	3.5	

SWITCHING CHARACTERISTICS (See Figure 1) (Note 2)

Turn-On Delay Time	Conditions for 2N4856,A, 2N4859,A: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 20 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -10 Vdc)	2N4856, 2N4859	$t_{d(on)}$	–	6.0	ns
		2N4856A, 2N4859A		–	5.0	
		2N4857, 2N4860		–	6.0	
		2N4857A, 2N4860A		–	6.0	
		2N4858, 2N4861		–	10	
		2N4858A, 2N4861A		–	8.0	
Rise Time	Conditions for 2N4857,A, 2N4860,A: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 10 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -6.0 Vdc)	2N4856,A, 2N4859,A	t_r	–	3.0	ns
		2N4857,A, 2N4860,A		–	4.0	
		2N4858, 2N4861		–	10	
		2N4858A, 2N4861A		–	8.0	
Turn-Off Time	Conditions for 2N4858,A, 2N4861,A: (V_{DD} = 10 Vdc, $I_{D(on)}$ = 5.0 mAdc, $V_{GS(on)}$ = 0, $V_{GS(off)}$ = -4.0 Vdc)	2N4856, 2N4859	t_{off}	–	25	ns
		2N4856A, 2N4859A		–	20	
		2N4857, 2N4860		–	50	
		2N4857A, 2N4860A		–	40	
		2N4858, 2N4861		–	100	
		2N4858A, 2N4861A		–	80	

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%.

Note 2: The $I_{D(on)}$ values are nominal; exact values vary slightly with transistor parameters.

2N5090 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency-multiplier or oscillator circuits in Military or Industrial equipment. Suitable for use as output, driver or pre-driver stages in VHF and UHF equipment.

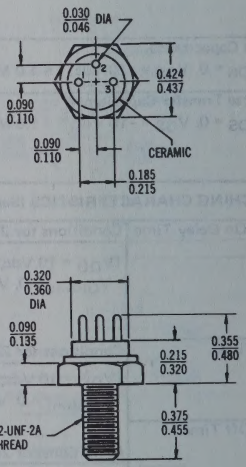
- 1.2 Watts Output Minimum at 400 MHz (7.8 dB Gain)
- 2.0 Watts Output Typical at 150 MHz (13 dB Gain)
- Multiple-Emitter Overlay Construction for Excellent High-Frequency Performance

NPN SILICON RF POWER TRANSISTOR

*MAXIMUM RATINGS

Ratings	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current - Continuous	I_C	0.4	Adc
Total Device Dissipation @ $T_C = 75^oC$ Derate above 75^oC	P_D	5.0 0.4	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*Indicates JEDEC Registered Data.



Pin 1. Emitter
2. Base
3. Collector

CASE 36
TO-60

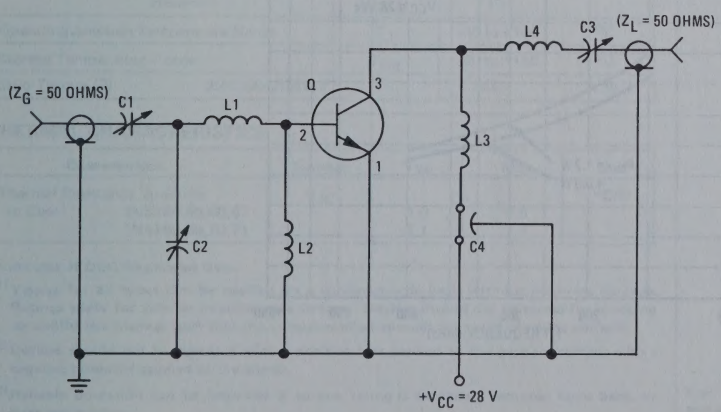
All Leads Isolated from Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	Vdc
Collector-Emitter Sustaining Voltage (I_C = 5.0 mAdc, R_{BE} = 10 Ohms)	$V_{CER(sus)}$	55	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	20	μAdc
Collector Cutoff Current (V_{CE} = 55 Vdc, V_{BE} = -1.5 Vdc) (V_{CE} = 30 Vdc, V_{BE} = -1.5 Vdc, T_C = 200°C)	I_{CEX}	– –	0.1 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 3.5 Vdc, I_C = 0)	I_{EBO}	–	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (I_C = 360 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10 5.0	200 –	–
Collector-Emitter Saturation Voltage (I_C = 0.1 Adc, I_B = 20 mAdc)	$V_{CE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	500	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = O, f = 1.0 MHz)	C_{ob}	–	3.5	pF
FUNCTIONAL TEST				
Power Input (Figure 1) (P_{out} = 1.2 Watts, R_L = 50 Ohms, f = 400 MHz)	P_{in}	–	0.2	Watt
Collector Efficiency (Figure 1) (P_{out} = 1.2 Watts, R_L = 50 Ohms, f = 400 MHz)	η	45	–	%

*Indicates JEDEC Registered Data.

FIGURE 1 – 400 MHz TEST CIRCUIT



C1 = 0.9–7.0 pF, ARCO 400 or equivalent
C2 = 1.5–20 pF, ARCO 402 or equivalent
C3 = 1.5–20 pF, ARCO 402 or equivalent
C4 = 1000 pF
L1 = 2 turns No. 18 AWG wire, 1/4" ID, 1/8" Long
L2 = RF Choke, 0.1 μH
L3 = 2 turns No. 18 AWG wire, 1/8" ID, 1/8" Long
L4 = 3 turns No. 16 AWG wire, 1/4" ID, 3/8" Long

FIGURE 2 – POWER OUTPUT versus FREQUENCY

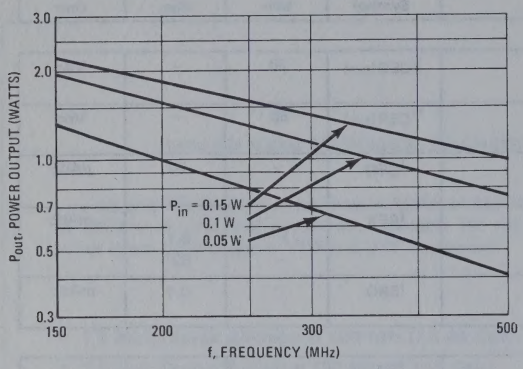


FIGURE 3 – POWER OUTPUT versus POWER INPUT

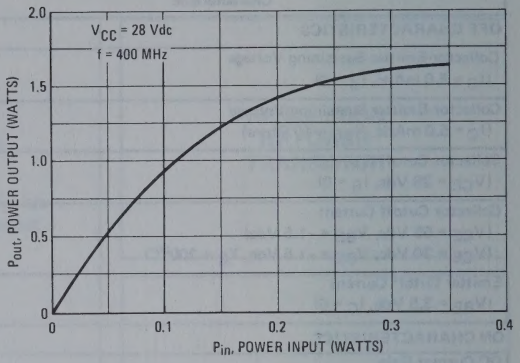


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

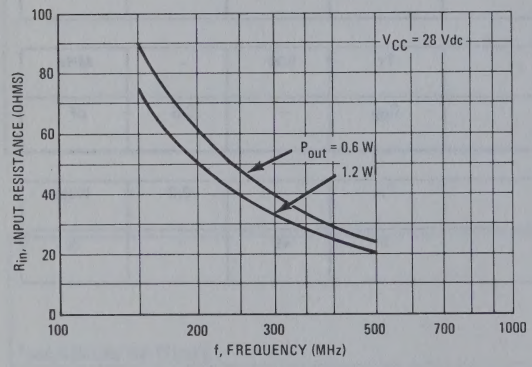


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

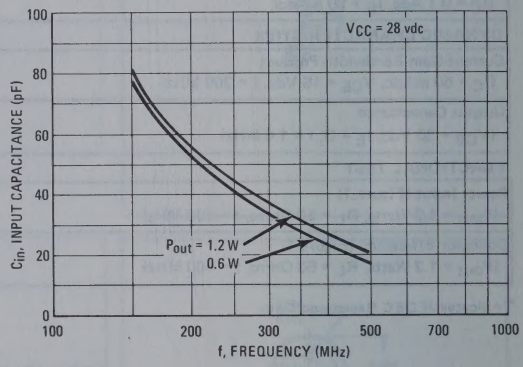
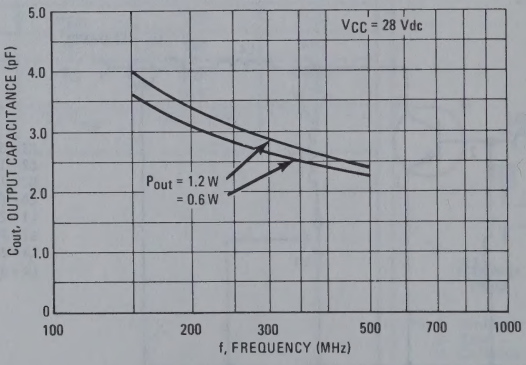


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY



2N5164 thru 2N5171 (SILICON)
2N5164R thru 2N5171R

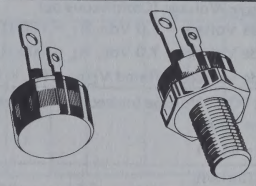
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Supplied in Either Pressfit or Stud Package
- High Surge Current Rating – I_{TSM} = 240 Amp
- Low On-State Voltage – 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics – 10 mA (Typ) @ T_C = 25°C

THYRISTORS
PNPN

50–600 VOLTS
20 AMPERES RMS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
*Peak Reverse Blocking Voltage (1) 2N5164,2N5168 2N5165,2N5169 2N5166,2N5170 2N5167,2N5171	V_{RRM}	 50 200 400 600	Volts
*Non-repetitive Peak Reverse Blocking Voltage 2N5164,2N5168 2N5165,2N5169 2N5166,2N5170 2N5167,2N5171	V_{RSM}	 75 300 500 700	Volts
Forward Current RMS	$I_{T(RMS)}$	20	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C, t ≤ 8.3 ms)	I^2t	235	A^2s
*Peak Forward Surge Current (One cycle, 60 Hz, T_J = -40 to +100°C)	I_{TSM}	240	Amp
*Peak Forward Gate Power	P_{GFM}	5.0	Watts
*Average Forward Gate Power	$P_{GF(AV)}$	0.5	Watt
*Peak Forward Gate Current	I_{GFM}	2.0	Amp
Peak Gate Voltage – Forward (2) Reverse	V_{GFM} V_{GRM}	10 10	Volts
*Operating Junction Temperature Range	T_J	-40 to +100	°C
*Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (3) 2N5168-2N5171		30	in. lb.

THERMAL CHARACTERISTICS

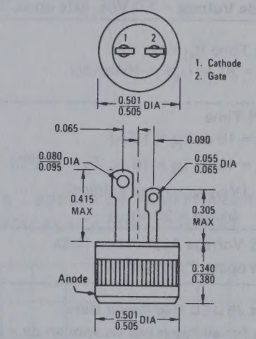
Characteristic	Symbol	Typ	Max	Unit
*Thermal Resistance, Junction to Case 2N5164,65,66,67 2N5168,69,70,71	θ_{JC}	 1.0 1.1	 1.5 1.6	°C/W

*Indicates JEDEC Registered Data.

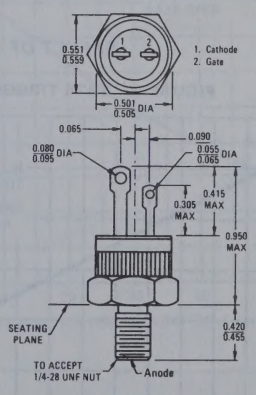
(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested for blocking capability in a manner such that the voltage applied exceeds the rated blocking voltage.

(2) Devices should not be operated with a positive bias applied to the gate concurrent with a negative potential applied to the anode.

(3) Reliable operation can be impaired if torque rating is exceeded, terminal tubes bent, or glass seal broken.



CASE 174 (1)



CASE 175 (1)

For "R Suffix devices: e.g., 2N5164R, the cathode and anode terminals are reversed.

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
*Peak Forward Blocking Voltage (T_J = 100°C) 2N5164, 2N5168	V_{DRM}(1)	50	–	Volts
2N5165, 2N5169		200	–	
2N5166, 2N5170		400	–	
2N5167, 2N5171		600	–	
*Peak Forward Blocking Current (Rated V_{DRM} @ T_J = 100°C, gate open)	I_{DRM}	–	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM} @ T_J = 100°C, gate open)	I_{RRM}	–	5.0	mA
Gate Trigger Current (Continuous dc)	I_{GT}(2)			mA
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		–	40	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)		–	75	
Gate Trigger Voltage (Continuous dc)	V_{GT}			Volts
(Anode Voltage = 7.0 Vdc, R_L = 100 Ω)		–	1.5	
*(Anode Voltage = 7.0 Vdc, R_L = 100 Ω, T_C = -40°C)		–	2.5	
*(Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	–	
Forward "ON" Voltage (pulsed, 1.0 ms max, duty cycle ≤1%)	V_{TM}			Volts
(I_{TM} = 20 A)		–	1.5	
(I_{TM} = 41 A)		–	1.7	
Holding Current	I_H			mA
(Anode Voltage = 7.0 Vdc, gate open)		–	50	
*(Anode Voltage = 7.0 Vdc, gate open, T_C = -40°C)		–	90	
		TYPICAL		
Turn-On Time (t_d + t_r) (I_{TM} = 20 A, I_{GT} = 40 mAdc)	t_{on}	1.0		μs
Turn-Off Time	t_{off}			μs
(I_{TM} = 10 A, I_R = 10 A)		20		
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C) (V_{DRM} = rated voltage) (dv/dt = 30 V/μs)		30		
Forward Voltage Application Rate (Gate open, T_J = 100°C)	dv/dt	50		V/μs

*Indicates JEDEC Registered Data.

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. These devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) For optimum operation, i.e. faster turn-on, lower switching losses, best di/dt capability, recommended I_{GT} = 200 mA.

EFFECT OF TEMPERATURE UPON TYPICAL TRIGGER CHARACTERISTICS

FIGURE 1 – GATE TRIGGER CURRENT

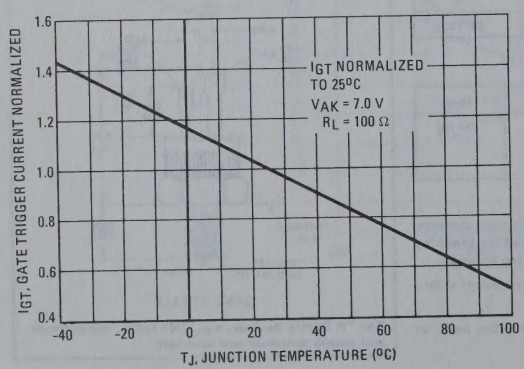
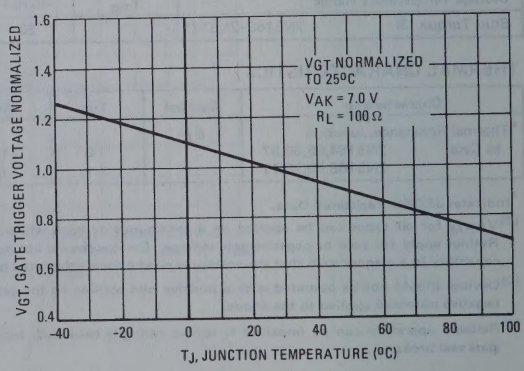


FIGURE 2 – GATE TRIGGER VOLTAGE



MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT

FIGURE 3 – 60 Hz SURGES

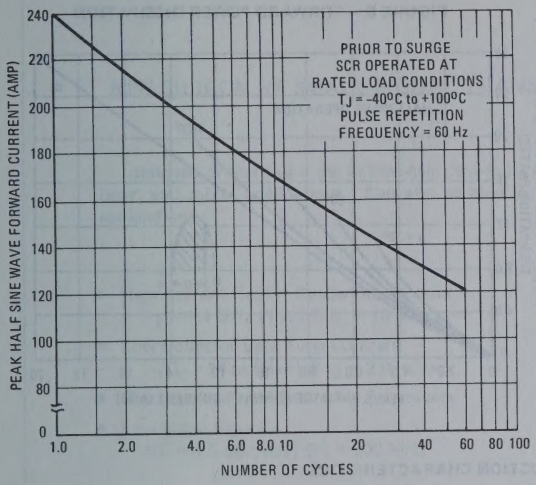


FIGURE 4 – SUB-CYCLE SURGES

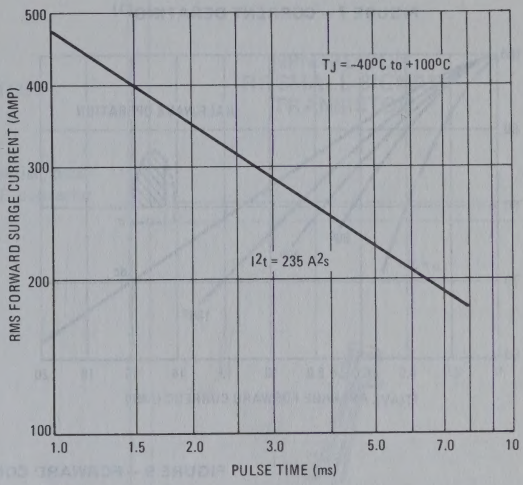


FIGURE 5 – GATE TRIGGER CHARACTERISTICS

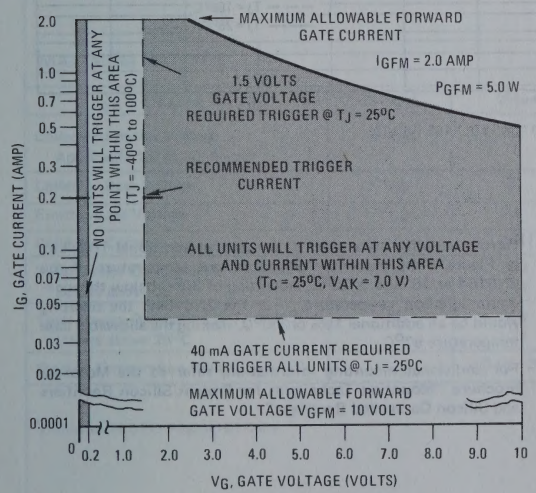
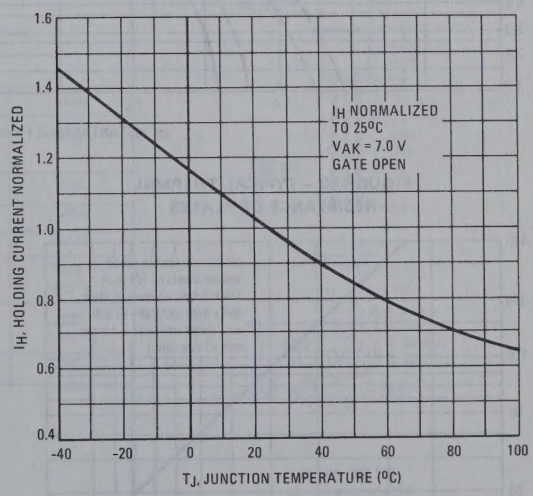


FIGURE 6 – EFFECT OF TEMPERATURE ON TYPICAL HOLDING CURRENT



DERATING AND DISSIPATION FOR RESISTIVE AND INDUCTIVE LOADS (f = 60 to 400 Hz, SINE WAVE)

FIGURE 7 – CURRENT DERATING[1]

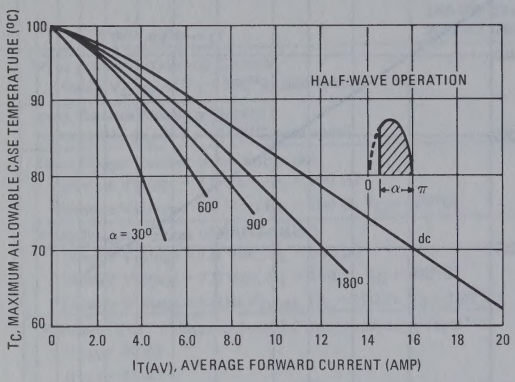


FIGURE 8 – FORWARD POWER DISSIPATION

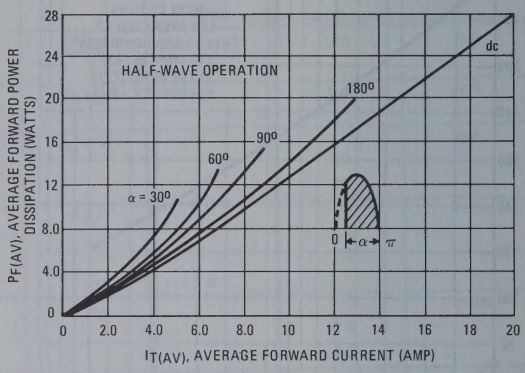


FIGURE 9 – FORWARD CONDUCTION CHARACTERISTICS

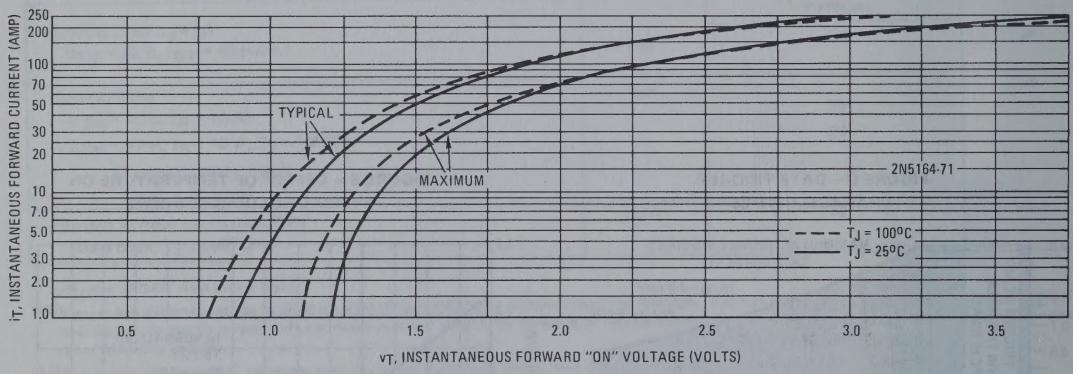
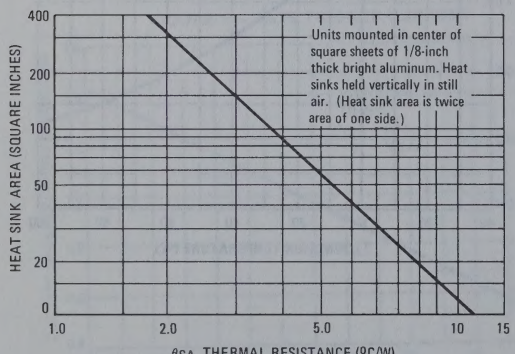


FIGURE 10 – TYPICAL THERMAL RESISTANCE OF PLATES


HEAT SINK AREA (SQUARE INCHES)
θSA, THERMAL RESISTANCE (°C/W)
Units mounted in center of square sheets of 1/8-inch thick bright aluminum. Heat sinks held vertically in still air. (Heat sink area is twice area of one side.)

(1) Reverse polarity units must be derated an additional 10%; i.e., in Figure 7 the maximum allowable case temperature of the 2N5164 at 16 Adc is 70°C, a derating of 30°C below the maximum junction temperature. For the 2N5164R the derating would be an additional 10% or 3.0°C, making the allowable case temperature 67°C.

For additional mounting information, refer to the Motorola brochure "Mounting Techniques for Pressfit Silicon Rectifiers and Silicon Controlled Rectifiers".

2N5179 (SILICON)

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

. . . designed primarily for use in high-gain, low-noise amplifier, oscillator, and mixer applications. Can also be used in UHF converter applications.

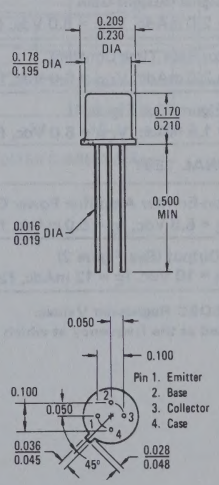
- High Current-Gain — Bandwidth Product — f_T = 1.4 GHz (Typ) @ I_C = 10 mAdc
- Low Collector-Base Time Constant — $r_b'C_c$ = 14 ps (Max) @ I_E = 2.0 mAdc
- Characterized with Scattering Parameters
- Low Noise Figure — NF = 4.5 dB (Max) @ f = 200 MHz

NPN SILICON RF SMALL-SIGNAL TRANSISTOR

*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage Applicable 1.0 to 20 mAdc	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	20	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 1.71	mW mW/°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Indicates JEDEC Registered Data.



CASE 20(10)
TO-72 PACKAGE

Active Elements Isolated from Case

*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage (I_C = 3.0 mAdc, I_B = 0)	$V_{CEO(sus)}$	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.001 mAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	2.5	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	– –	0.02 1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 3.0 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	25	250	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product ① (I_C = 5.0 mAdc, V_{CE} = 6.0 Vdc, f = 100 MHz)	f_T	900	2000	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{cb}	–	1.0	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)	h_{fe}	25	300	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 6.0 Vdc, f = 31.9 MHz)	$r_b'C_c$	3.0	14	ps
Noise Figure (See Figure 1) (I_C = 1.5 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	–	4.5	dB
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (See Figure 1) (V_{CE} = 6.0 Vdc, I_C = 5.0 mAdc, f = 200 MHz)	G_{pe}	15	–	dB
Power Output (See Figure 2) (V_{CB} = 10 Vdc, I_E = 12 mAdc, f≥500 MHz)	P_{out}	20	–	mW

*Indicates JEDEC Registered Values.

① f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

FIGURE 1 – 200 MHz AMPLIFIER POWER GAIN AND NOISE FIGURE CIRCUIT

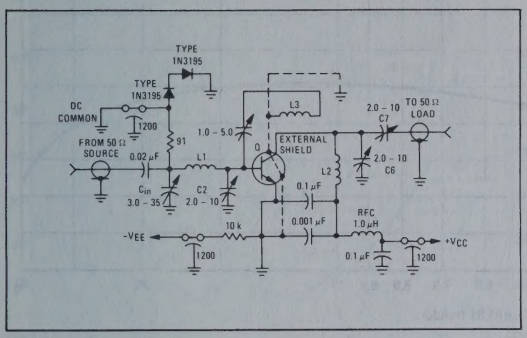


FIGURE 2 – 500 MHz OSCILLATOR CIRCUIT

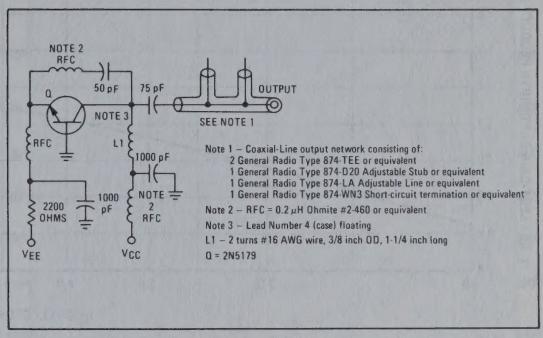

NOTE 2 RFC
50 pF
75 pF
OUTPUT
Q
NOTE 3
SEE NOTE 1
RFC
L1
1000 pF
2200 OHMS
1000 pF
NOTE 2 RFC
VEE
VCC
Note 1 – Coaxial-Line output network consisting of:
2 General Radio Type 874-TEE or equivalent
1 General Radio Type 874-D20 Adjustable Stub or equivalent
1 General Radio Type 874-LA Adjustable Line or equivalent
1 General Radio Type 874-WN3 Short-circuit termination or equivalent
Note 2 – RFC = 0.2 μH Ohmite #2460 or equivalent
Note 3 – Lead Number 4 (case) floating
L1 – 2 turns #16 AWG wire, 3/8 inch OD, 1-1/4 inch long
Q = 2N5179

FIGURE 3 – NOISE FIGURE versus FREQUENCY

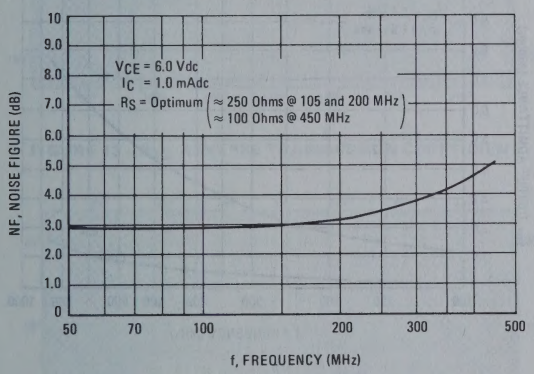


FIGURE 4 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

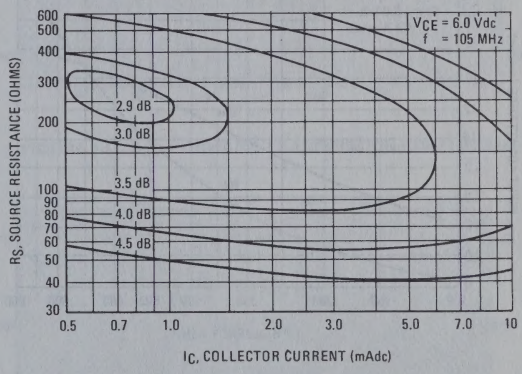


FIGURE 5 – NOISE FIGURE versus SOURCE RESISTANCE and COLLECTOR CURRENT

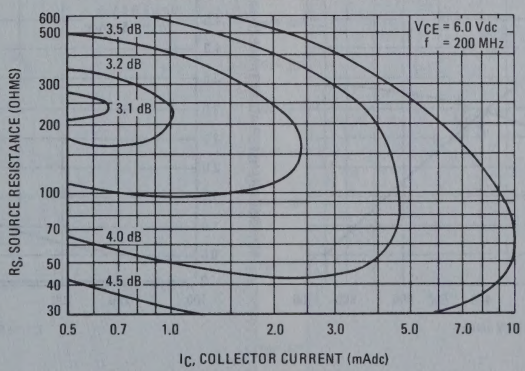


FIGURE 6 – CURRENT-GAIN-BANDWIDTH PRODUCT

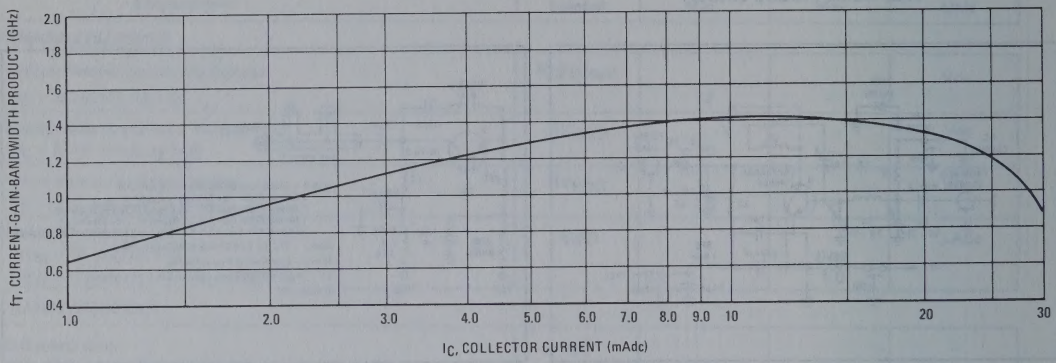


FIGURE 7 – INPUT ADMITTANCE versus FREQUENCY

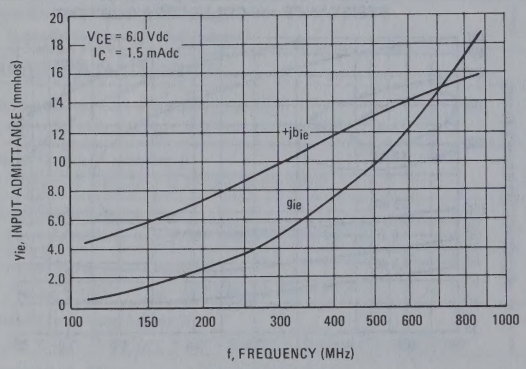


FIGURE 8 – OUTPUT ADMITTANCE versus FREQUENCY

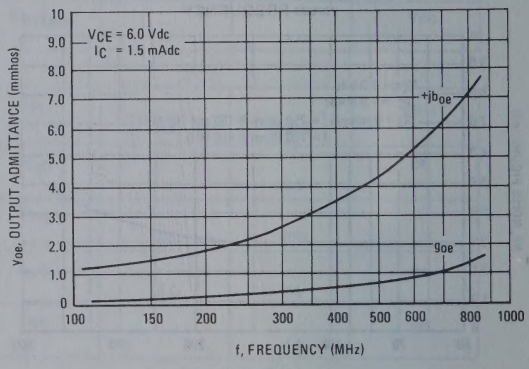


FIGURE 9 – FORWARD TRANSFER ADMITTANCE versus FREQUENCY

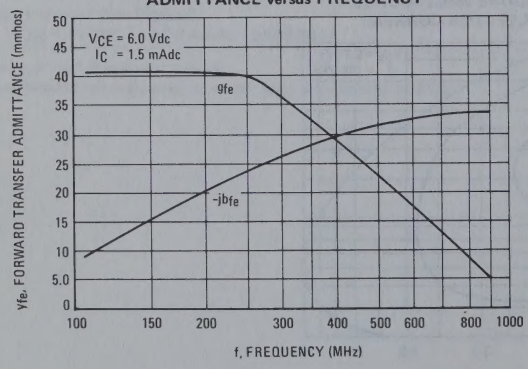


FIGURE 10 – REVERSE TRANSFER ADMITTANCE versus FREQUENCY

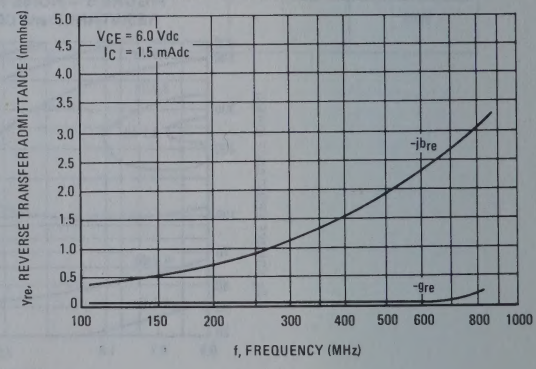


FIGURE 11— S_{11}, INPUT REFLECTION COEFFICIENT

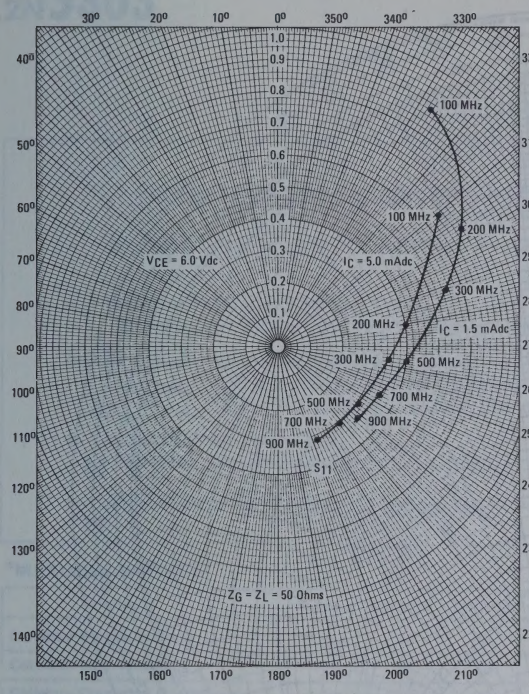


FIGURE 12—S_{22}, OUTPUT REFLECTION COEFFICIENT

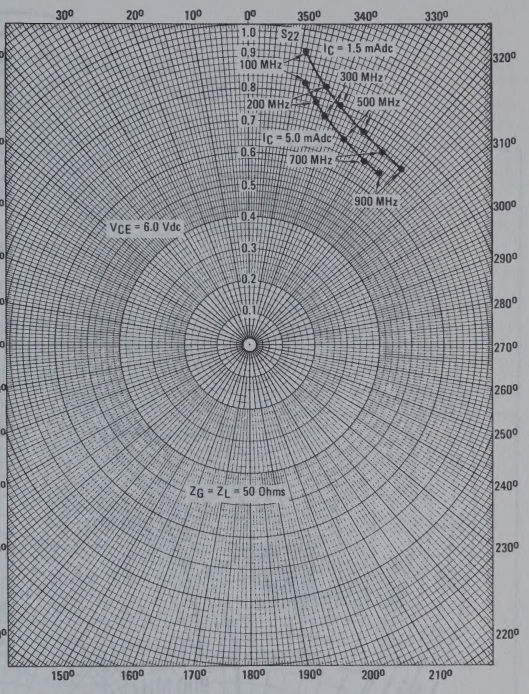


FIGURE 13 — S_{12}, REVERSE TRANSMISSION COEFFICIENT

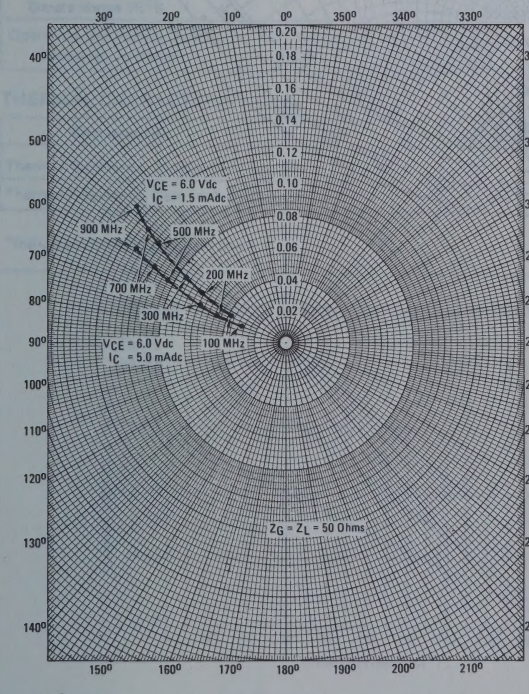


FIGURE 14 — S_{21}, FORWARD TRANSMISSION COEFFICIENT

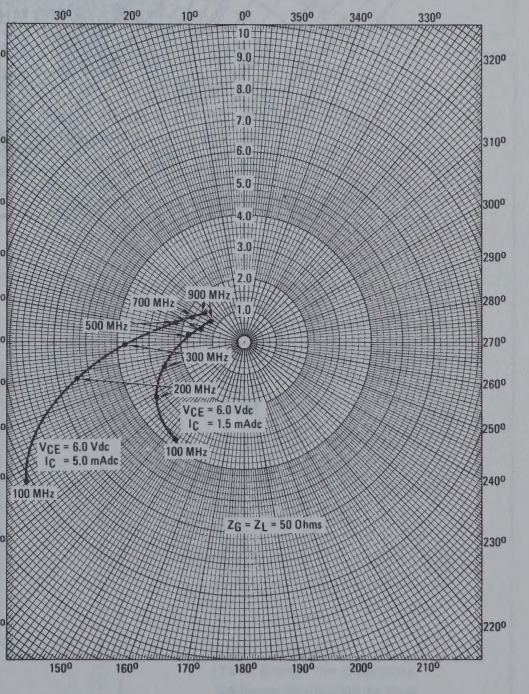
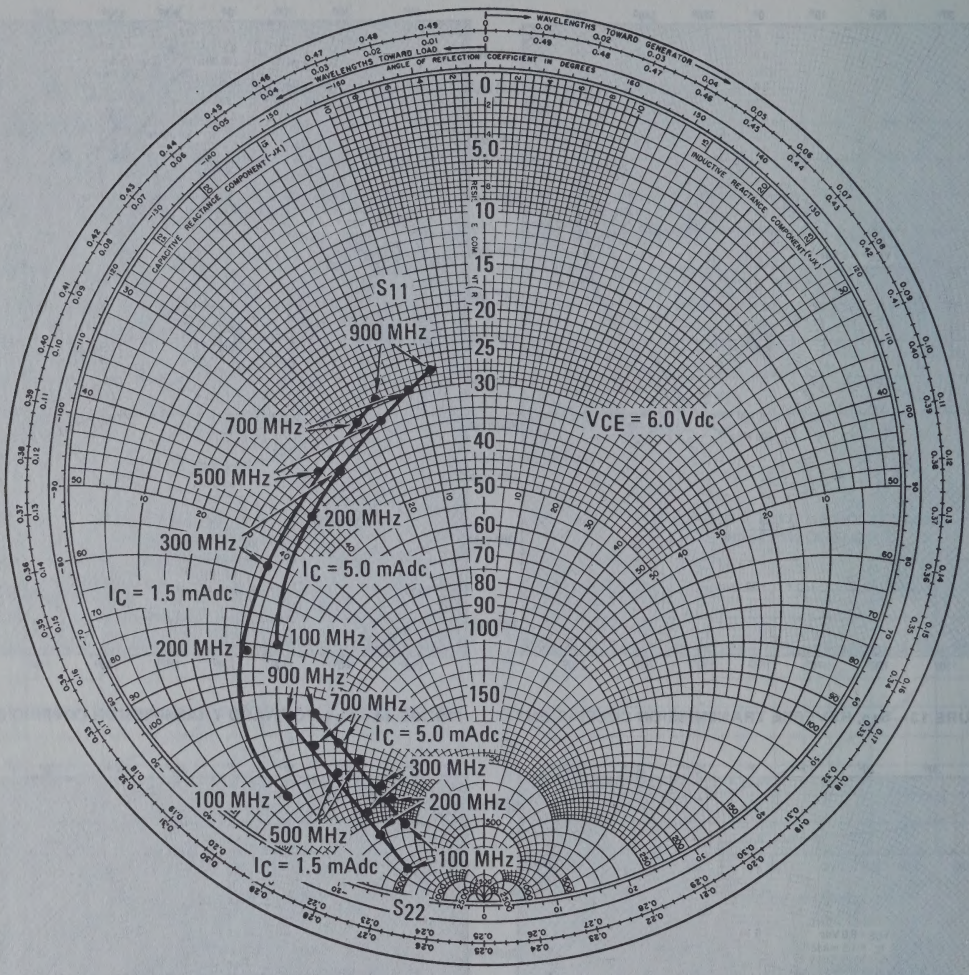


FIGURE 15 – S_{11}, INPUT REFLECTION COEFFICIENT AND S_{22}, OUTPUT REFLECTION COEFFICIENT



2N5301 (SILICON)
2N5302
2N5303

HIGH-POWER NPN SILICON TRANSISTORS

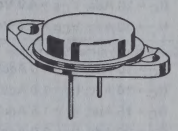
. . . for use in power amplifier and switching circuits applications.

- High Collector-Emitter Sustaining Voltage —
  $BV_{CEO(sus)}$ = 80 Vdc (Min) @ I_C = 200 mAdc (2N5303)
- Low Collector-Emitter Saturation Voltage —
  $V_{CE(sat)}$ = 0.75 Vdc (Max) @ I_C = 10 Adc (2N5301, 2N5302)
  1.0 Vdc (Max) @ I_C = 10 Adc (2N5303)
- Excellent Safe Operating Area —
  200 Watts dc Power Rating to 30 Vdc (2N5303)
- Complements to PNP 2N4398, 2N4399 and 2N5745

20 AND 30 AMPERE POWER TRANSISTORS

NPN SILICON

40-60-80 VOLTS
200 WATTS



*MAXIMUM RATINGS

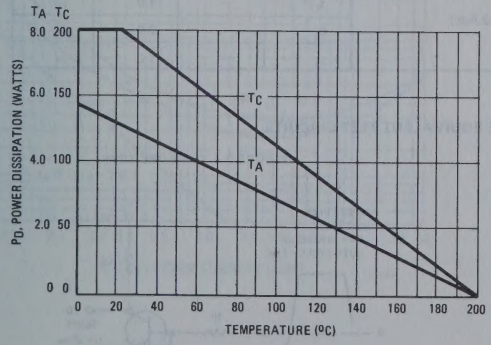
Rating	Symbol	2N5301	2N5302	2N5303	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Collector Current — Continuous	I_C	30	30	20	Adc
Base Current	I_B	← 7.5 →			Adc
Total Device Dissipation @ T_C=25°C Derate above 25°C	P_D	← 200 → ← 1.14 →			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	← -65 to +200 →			°C

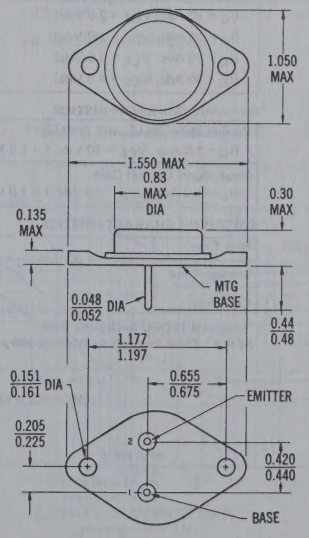
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.875	°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	34	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 — POWER TEMPERATURE DERATING CURVE





CASE 12
(TO-3 Except Pin Diameter)
Collector Connected to Case

2N5301, 2N5302, 2N5303 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25° unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
***OFF CHARACTERISTICS**					
Collector-Emitter Sustaining Voltage (Note 1)		$V_{CEO(sus)}$			Vdc
(I_C = 200 mAdc, I_B = 0)	2N5301		40	–	
	2N5302		60	–	
	2N5303		80	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N5301		–	5.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N5302		–	5.0	
(V_{CE} = 80 Vdc, I_B = 0)	2N5303		–	5.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5301		–	1.0	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5302		–	1.0	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5303		–	1.0	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5301		–	10	
(V_{CE} = 60 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5302		–	10	
(V_{CE} = 80 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 150°C)	2N5303		–	10	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N5301		–	1.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N5302		–	1.0	
(V_{CB} = 80 Vdc, I_E = 0)	2N5303		–	1.0	
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
*(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	ALL TYPES		40	–	
*(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5303		15	60	
*(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N5301,2N5302		15	60	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5303		5.0	–	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N5301,2N5302		5.0	–	
*Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	2N5301,2N5302		–	0.75	
(I_C = 10 Adc, I_B = 1.0 Adc)	2N5303		–	1.0	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5303		–	1.5	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N5301,2N5302		–	2.0	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5303		–	2.0	
(I_C = 30 Adc, I_B = 6.0 Adc)	2N5301,2N5302		–	3.0	
*Base-Emitter Saturation Voltage (Note 1)		$V_{BE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)	ALL TYPES		–	1.7	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5301,2N5302		–	1.8	
(I_C = 15 Adc, I_B = 1.5 Adc)	2N5303		–	2.0	
(I_C = 20 Adc, I_B = 2.0 Adc)	2N5301,2N5302		–	2.5	
(I_C = 20 Adc, I_B = 4.0 Adc)	2N5303		–	2.5	
*Base-Emitter On Voltage (Note 1)		$V_{BE(on)}$			Vdc
(I_C = 10 Adc, V_{CE} = 2.0 Vdc)	2N5303		–	1.5	
(I_C = 15 Adc, V_{CE} = 2.0 Vdc)	2N5301,2N5302		–	1.7	
(I_C = 20 Adc, V_{CE} = 4.0 Vdc)	2N5303		–	2.5	
(I_C = 30 Adc, V_{CE} = 4.0 Vdc)	2N5301,2N5302		–	3.0	
***DYNAMIC CHARACTERISTICS**					
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	–	MHz
Small-Signal Current Gain (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	40	–	–
***SWITCHING CHARACTERISTICS**					
Rise Time	(V_{CC} = 30 Vdc, I_C = 10 Adc, I_{B1} = I_{B2} = 1.0 Adc)	t_r	–	1.0	μs
Storage Time		t_s	–	2.0	μs
Fall Time		t_f	–	1.0	μs

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 2 – TURN-ON TIME

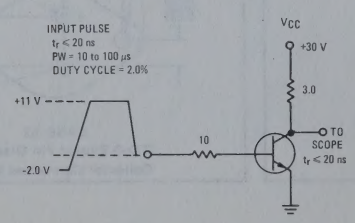


FIGURE 3 – TURN-OFF TIME

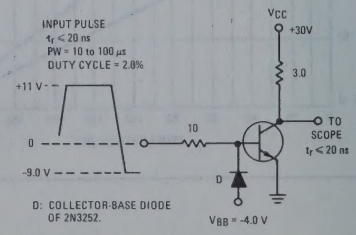


FIGURE 4 – THERMAL RESPONSE

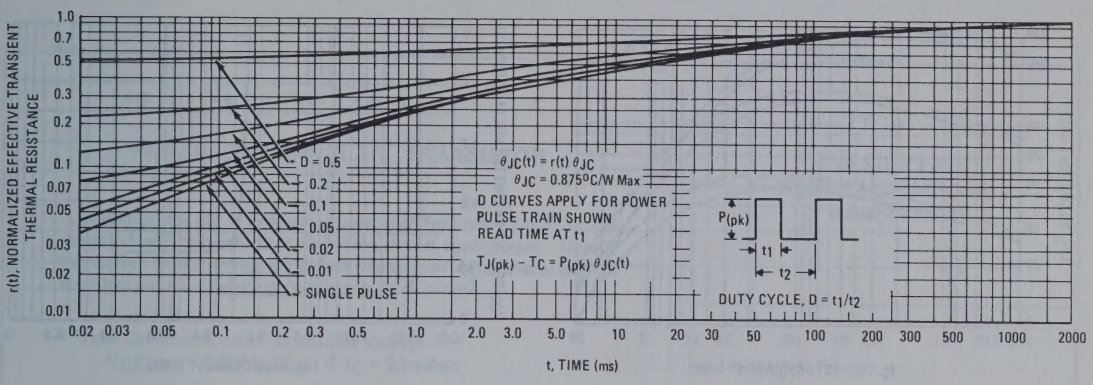


FIGURE 5 – ACTIVE-REGION SAFE OPERATING AREA

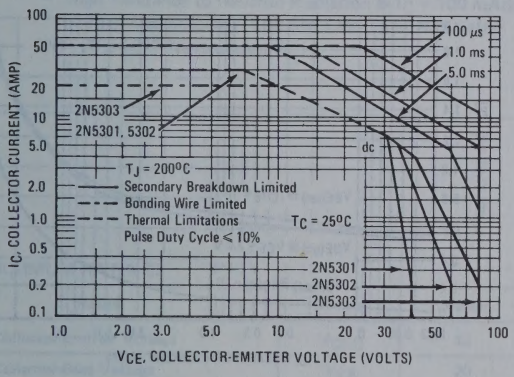


FIGURE 6 – CAPACITANCE versus VOLTAGE

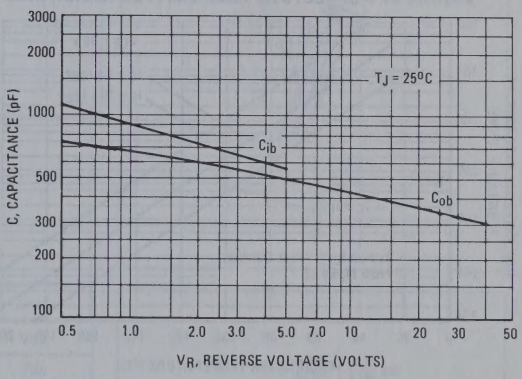


FIGURE 7 – TURN-ON TIME

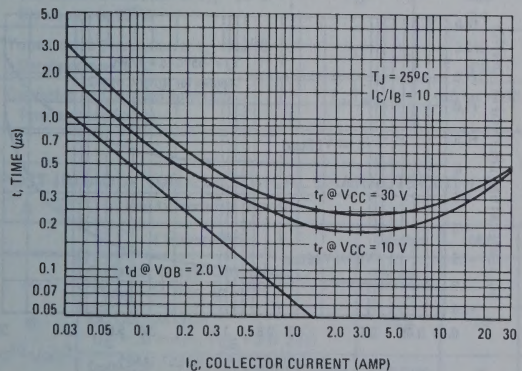


FIGURE 8 – TURN-OFF TIME

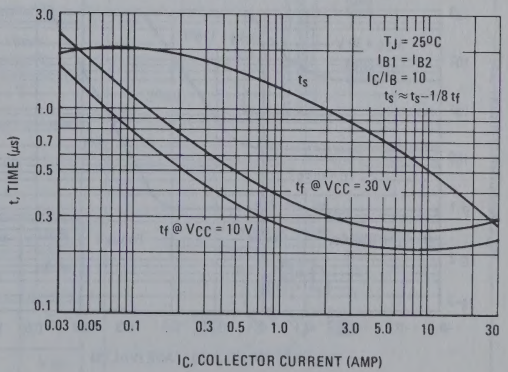


FIGURE 9 – DC CURRENT GAIN

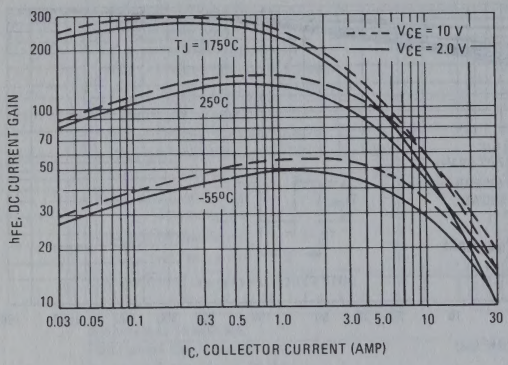


FIGURE 10 – COLLECTOR SATURATION REGION

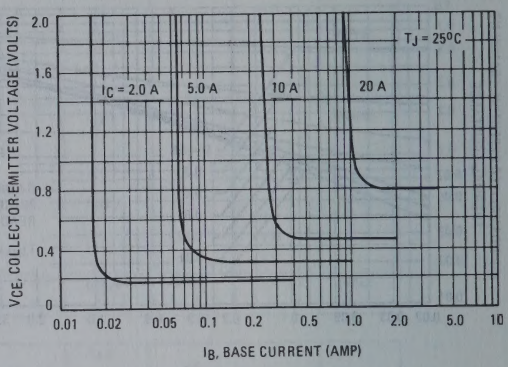


FIGURE 11 – EFFECTS OF BASE-EMITTER RESISTANCE

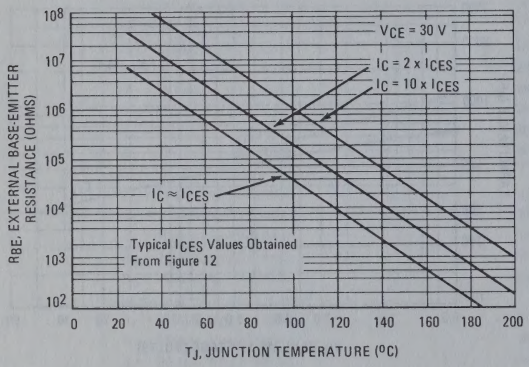

V_{CE} = 30 V
I_C = 2 x I_{CES}
I_C = 10 x I_{CES}
$I_C \approx I_{CES}$
Typical I_{CES} Values Obtained From Figure 12
R_{BE}, EXTERNAL BASE-EMITTER RESISTANCE (OHMS)
T_J, JUNCTION TEMPERATURE (°C)

FIGURE 12 – "ON" VOLTAGES

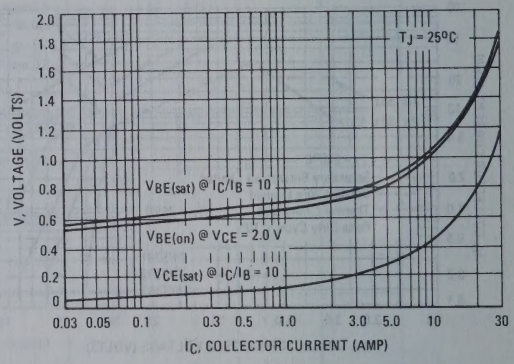


FIGURE 13 – COLLECTOR CUT-OFF REGION

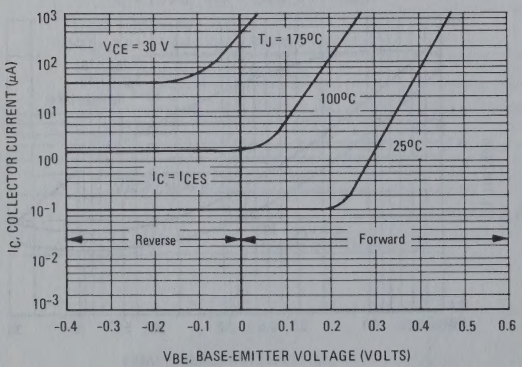
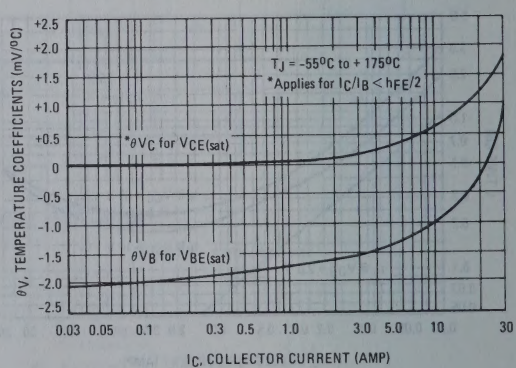


FIGURE 14 – TEMPERATURE COEFFICIENTS


T_J = -55°C to + 175°C
*Applies for $I_C/I_B < h_{FE}/2$
*θVC for $V_{CE(sat)}$
θVB for $V_{BE(sat)}$
θV, TEMPERATURE COEFFICIENTS (mV/°C)
I_C, COLLECTOR CURRENT (AMP)

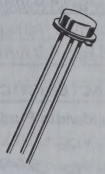
2N5332 (SILICON)

PNP SILICON ANNULAR TRANSISTOR

. . . designed for use in general-purpose, high-frequency amplifier and saturated and non-saturated switching circuit applications. Unique fabrication techniques are employed to maintain useful characteristics after fast-neutron radiation fluences to 10^{15} n/cm^2.

- Low Collector-Emitter Saturation Voltage – $V_{CE(sat)}$ = 0.2 Vdc (Max) @ I_C = 20 mAdc
- High Current-Gain–Bandwidth Product – f_T = 2300 MHz (Typ) @ I_C = 50 mAdc
- High Tolerance to Neutron Radiation @ I_C = 100 mAdc, h_{FE} Degradation Typically Less Than 40% after 3 x 10^{15} Neutrons/cm^2

PNP SILICON GENERAL-PURPOSE TRANSISTOR



MAXIMUM RATINGS

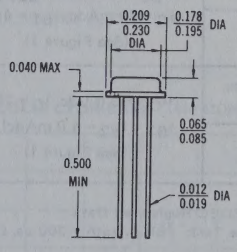
Rating	Symbol	Value	Unit
*Collector-Emitter Voltage	V_{CEO}	12	Vdc
*Collector-Base Voltage	V_{CB}	20	Vdc
*Emitter-Base Voltage	V_{EB}	2.0	Vdc
*Collector Current – Continuous	I_C	100	mAdc
*Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	360 2.4	mW mW/°C
*Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

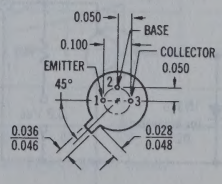
*POST-IRRADIATION ELECTRICAL CHARACTERISTICS

(T_A = 25°C unless otherwise noted)

	Characteristic	Symbol	Min	Max	Unit
Φ_n @ 10^{15}n/cm^2	Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	10	μAdc
	DC Current Gain (I_C = 20 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}	10	–	–
	Collector-Emitter Saturation Voltage (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{CE(sat)}$	–	0.6	Vdc

*Indicates JEDEC Registered Data.





CASE 26
TO-46 PACKAGE

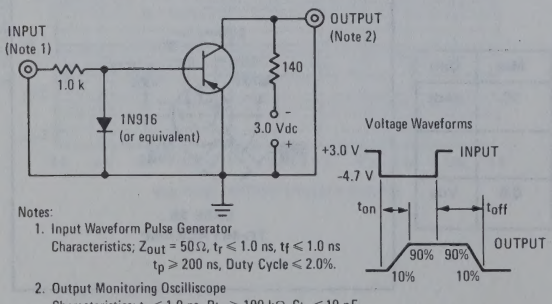
2N5332 (continued)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	2.0	–	Vdc
Collector Cutoff Current	I_{CBO}			
(V_{CB} = 15 Vdc, I_E = 0)		–	10	nAdc
(V_{CB} = 15 Vdc, I_E = 0, T_A = 125°C)		–	10	μAdc
Emitter Cutoff Current (V_{BE} = 1.5 Vdc, I_C = 0)	I_{EBO}	–	1.0	μAdc
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			–
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)		20	80	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (Note 1)		20	80	
(I_C = 20 mAdc, V_{CE} = 1.0 Vdc) (Note 1)		20	80	
(I_C = 20 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (Note 1)		10	–	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc) (Note 1)		20	80	
Collector-Emitter Saturation Voltage (Note 1) (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{CE(sat)}$	–	0.2	Vdc
Base-Emitter Saturation Voltage (Note 1) (I_C = 20 mAdc, I_B = 4.0 mAdc)	$V_{BE(sat)}$	0.7	1.0	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product	f_T			MHz
(I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		600	–	
(I_C = 50 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)		800	–	
Collector-Base Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{cb}	–	3.5	pF
Emitter-Base Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{eb}	–	8.0	pF
SWITCHING CHARACTERISTICS				
Delay Time (V_{CC} = 3.0 Vdc, $V_{BE(off)}$ = 0.7 Vdc, I_C = 20 mAdc, I_{B1} = 4.0 mAdc) (See Figure 1)	t_d	–	12	ns
Rise Time	t_r	–	8.0	ns
Storage Time (V_{CC} = 3.0 Vdc, I_C = 20 mAdc, I_{B1} = I_{B2} = 4.0 mAdc) (See Figure 1)	t_s	–	70	ns
Fall Time	t_f	–	16	ns

*Indicates JEDEC Registered Data.
Note 1: Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT



Notes:
1. Input Waveform Pulse Generator Characteristics; Z_{out} = 50 Ω, t_r ≤ 1.0 ns, t_f ≤ 1.0 ns t_p ≥ 200 ns, Duty Cycle ≤ 2.0%.
2. Output Monitoring Oscilliscope Characteristics; t_r ≤ 1.0 ns, R_{in} ≥ 100 kΩ, C_{in} ≤ 10 pF.

FIGURE 2 – DC CURRENT GAIN

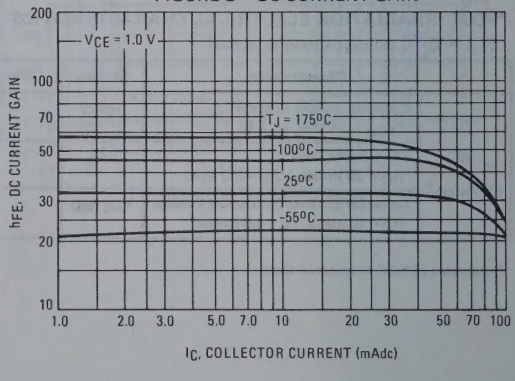


FIGURE 3 – "ON" VOLTAGES

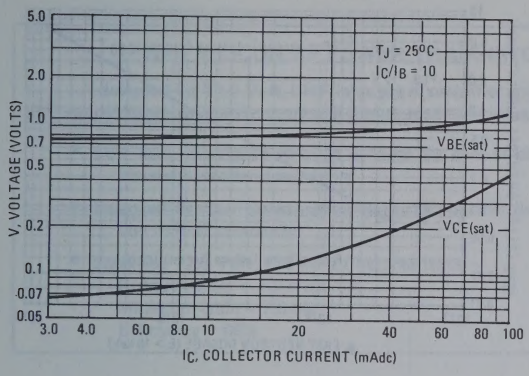


FIGURE 4 – COLLECTOR SATURATION REGION

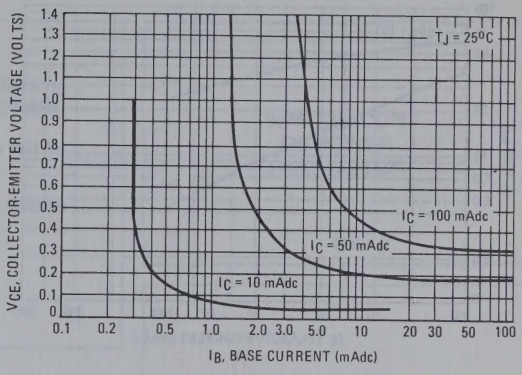


FIGURE 5 – TEMPERATURE COEFFICIENTS

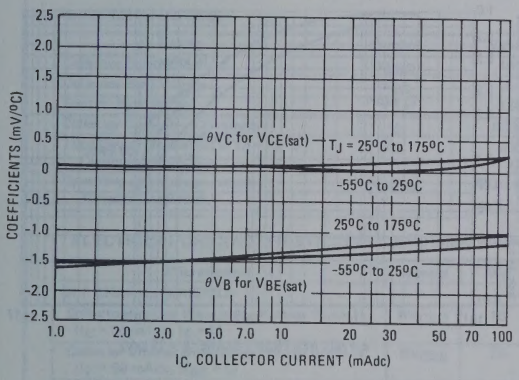


FIGURE 6 – CAPACITANCES

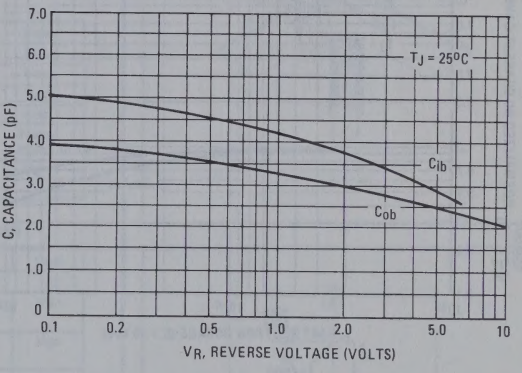


FIGURE 7 – CURRENT-GAIN–BANDWIDTH PRODUCT

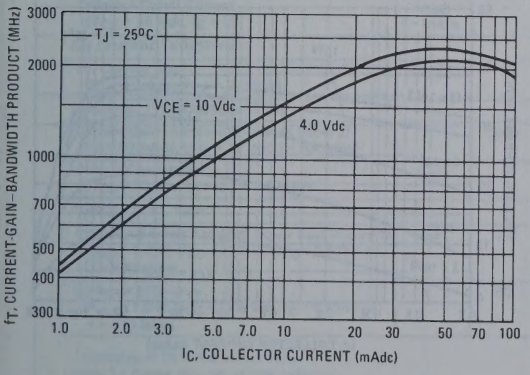


FIGURE 8 – COLLECTOR-BASE TIME CONSTANT

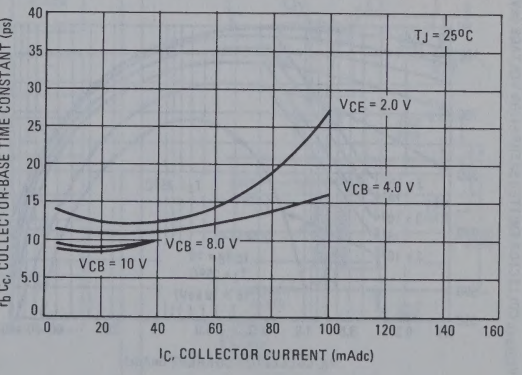


FIGURE 9 – SWITCHING TIMES

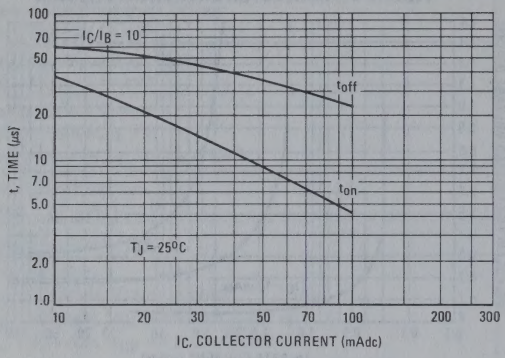


FIGURE 10 – COLLECTOR-CUTOFF CURRENT versus FAST NEUTRON DOSAGE

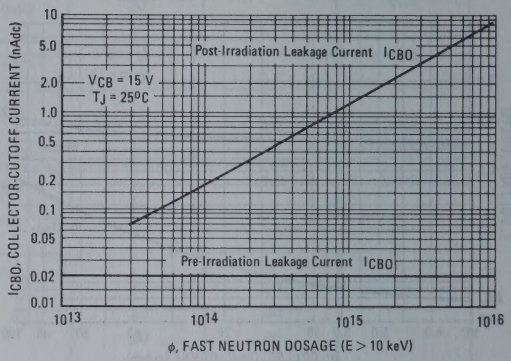

Post-Irradiation Leakage Current ICBO
VCB = 15 V
TJ = 25°C
Pre-Irradiation Leakage Current ICBO
ICBO, COLLECTOR-CUTOFF CURRENT (nAdc)
ϕ, FAST NEUTRON DOSAGE (E > 10 keV)

FIGURE 11 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

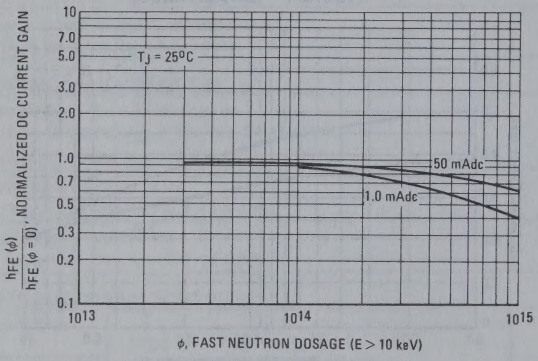


FIGURE 12 – NORMALIZED DC CURRENT GAIN versus FAST NEUTRON DOSAGE

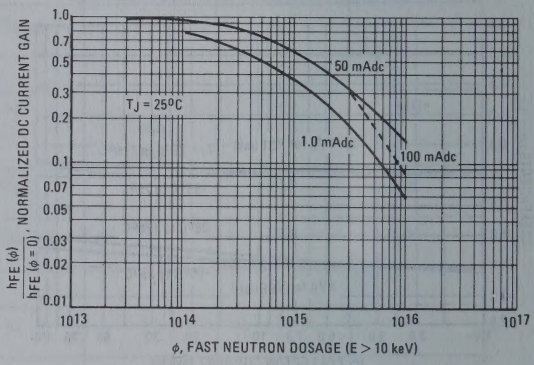


FIGURE 13 – TYPICAL COLLECTOR-EMITTER SATURATION VOLTAGE versus FAST NEUTRON DOSAGE

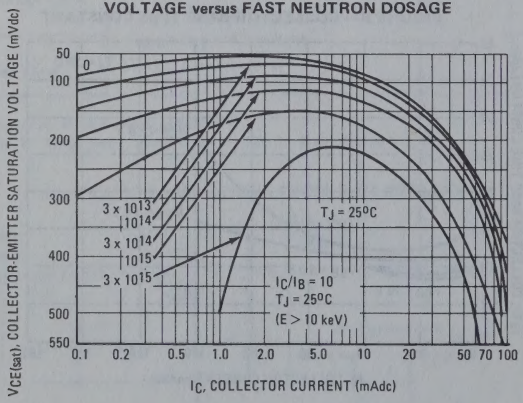
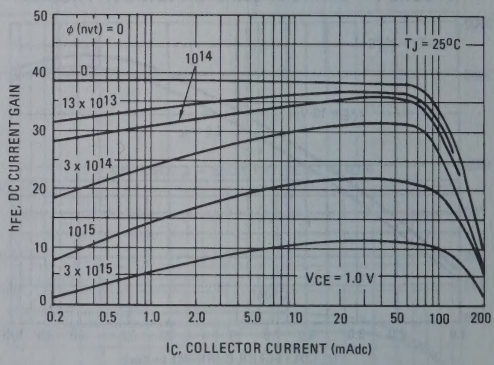


FIGURE 14 – DC CURRENT GAIN versus FAST NEUTRON DOSAGE



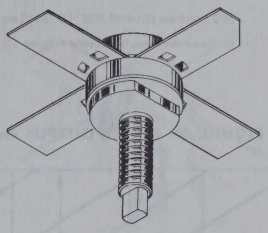
2N5644 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 1.0 Watt
  Minimum Gain = 7.0 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR



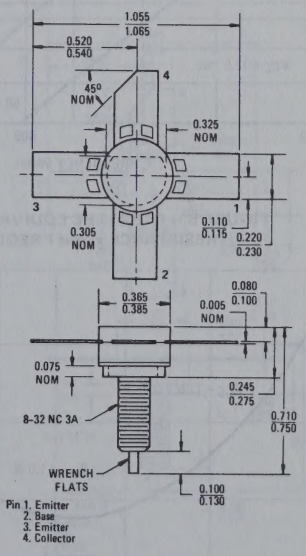
*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.25	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	3.5 0.02	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 50 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 50 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.1	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.1 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (Note 2) (I_C = 50 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	8.0	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 1.0 W, V_{CC} = 12.5 Vdc, I_C = 0.133 Adc, f = 470 MHz)	G_{PE}	7.0	–	dB
Collector Efficiency (P_{out} = 1.0 W, V_{CC} = 12.5 Vdc, I_C = 0.133 Adc, f = 470 MHz)	η	60	–	%

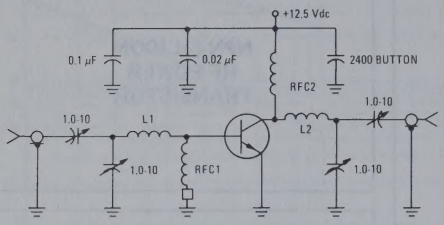
*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 145A-01

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



L1 = COPPER STRAP 1" Long, 5/32" Wide

L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

RFC 1 = 0.15 μH MOLDED CHOKE with Ferrite Bead on Ground Lead.

RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

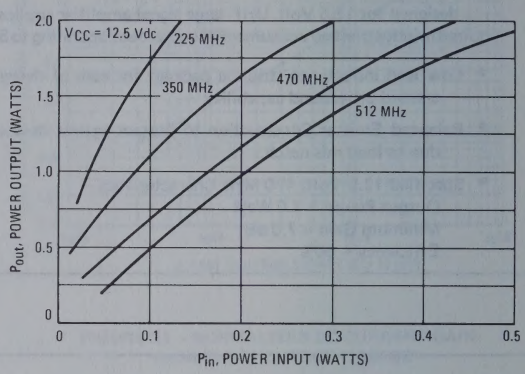


FIGURE 3 – POWER OUTPUT versus FREQUENCY

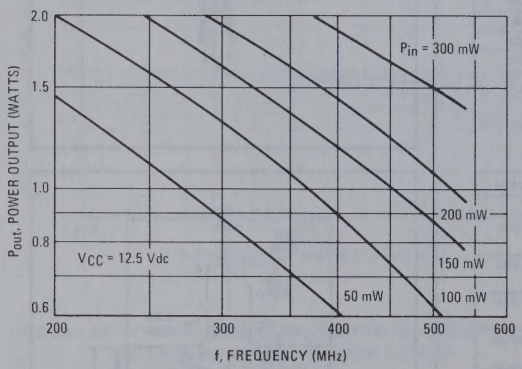


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

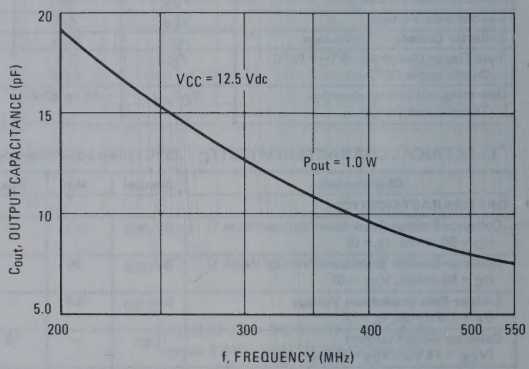


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

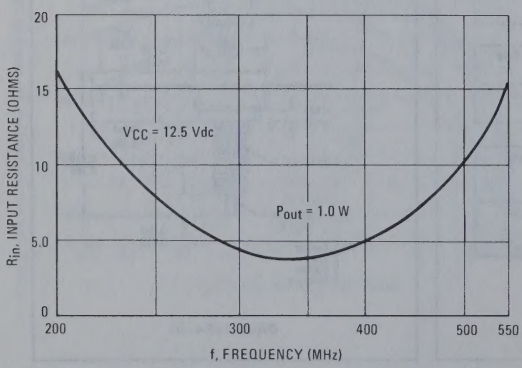
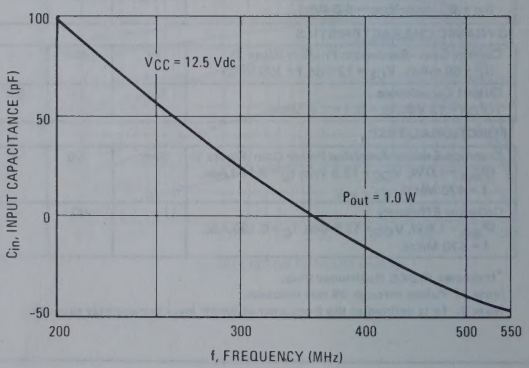


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



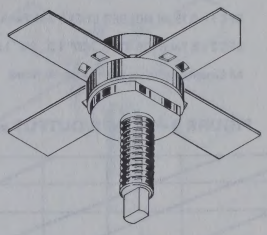
2N5645 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics —
  Output Power = 4.0 Watt
  Minimum Gain = 6.0 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	12 0.068	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

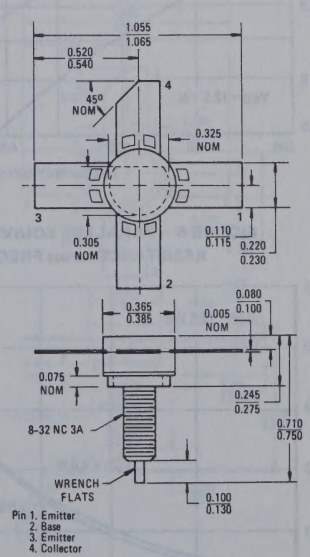
*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 100 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	0.5	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (Note 2) (I_C = 100 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	20	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C = 0.53 Adc, f = 470 MHz)	G_{PE}	6.0	–	dB
Collector Efficiency (P_{out} = 4.0 W, V_{CC} = 12.5 Vdc, I_C = 0.53 Adc, f = 470 MHz)	η	60	–	%

*Indicates JEDEC Registered Data.

Note 1: Pulsed through 25 mH inductor.

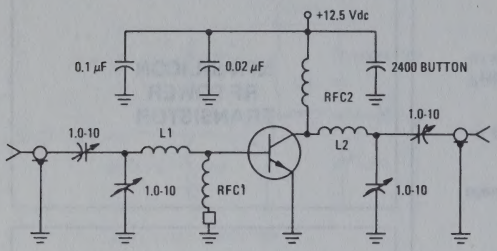
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.



CASE 145A-01

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



L1 = COPPER STRAP 1" Long, 5/32" Wide

L2 = 1 Turn #16 AWG WIRE, 3/32" I.D., Total Length of Coil and Leads = 13/16"

RFC 1 = 0.15 μH MOLDED CHOKE with Ferrite Bead on Ground Lead

RFC 2 = 8 Turns #20 WIRE, 7/32" I.D., 3/8" Long

All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

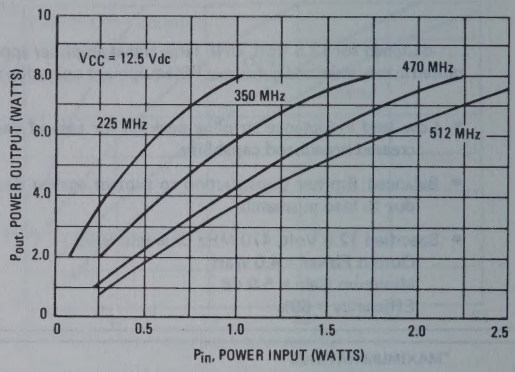


FIGURE 3 – POWER OUTPUT versus FREQUENCY

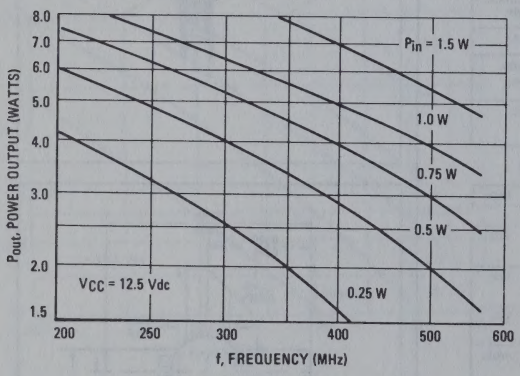


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

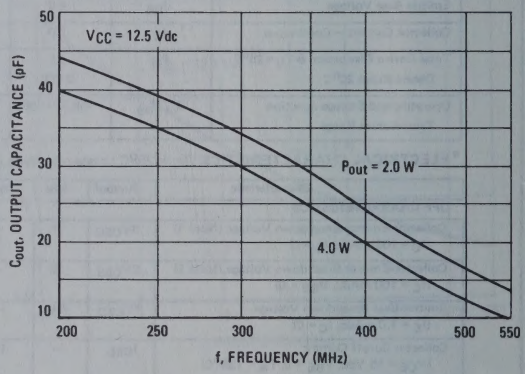


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

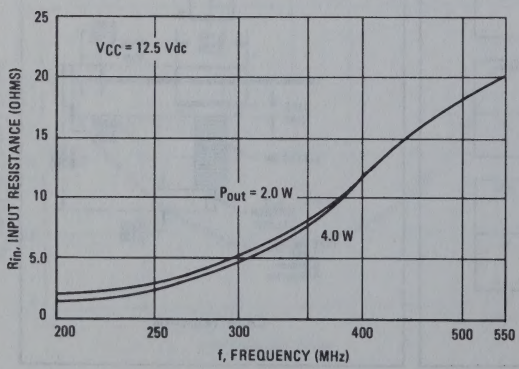
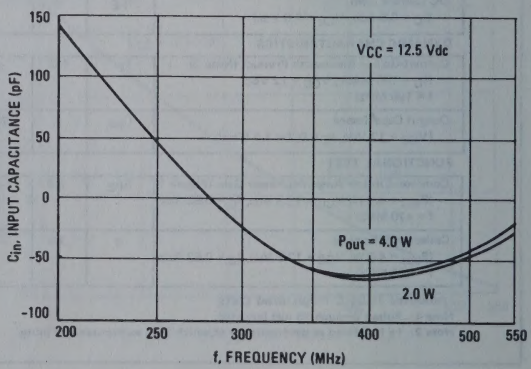


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



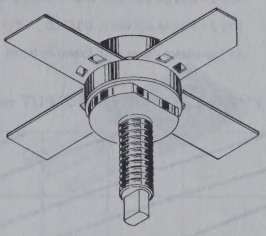
2N5646 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for 12.5 Volt, UHF large signal amplifier applications required in industrial and consumer FM equipment operating to 520 MHz.

- Low lead inductance stripline package for ease of design and increased broadband capability
- Balanced Emitter Construction to protect against device damage due to load mismatch
- Specified 12.5 Volt, 470 MHz Characteristics –
  Output Power = 12 Watt
  Minimum Gain = 4.7 dB
  Efficiency = 60%

NPN SILICON RF POWER TRANSISTOR

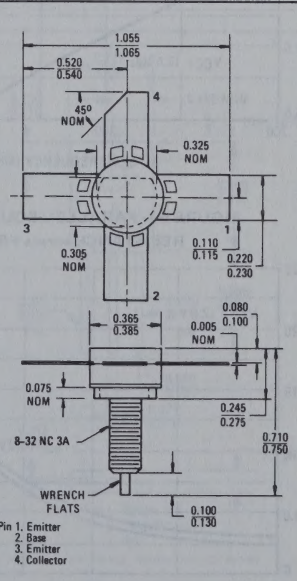


*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	36	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	2.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	30 0.171	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	^oC

*ELECTRICAL CHARACTERISTICS ($T_C = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	18	–	Vdc
Collector-Emitter Breakdown Voltage (Note 1) (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	36	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0, $T_A = 125^oC$)	I_{CES}	–	10	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 1.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	15	–	–
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (Note 2) (I_C = 250 mAdc, V_{CE} = 12 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 12 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	40	pF
FUNCTIONAL TEST				
Common-Emitter Amplifier Power Gain (Figure 1) (P_{out} = 12 W, V_{CC} = 12.5 Vdc, I_C = 1.6 Adc, f = 470 MHz)	G_{PE}	4.7	–	dB
Collector Efficiency (P_{out} = 12 W, V_{CC} = 12.5 Vdc, I_C = 1.6 Adc, f = 470 MHz)	η	60	–	%

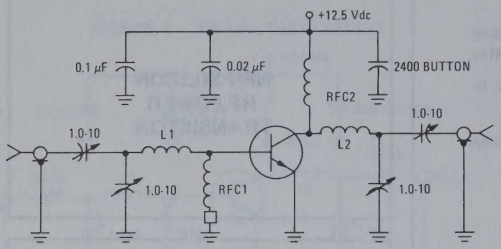


CASE 145A-01

*Indicates JEDEC Registered Data.
Note 1: Pulsed through 25 mH inductor.
Note 2: f_T is defined as the frequency at which $|h_{fe}|$ extrapolates to unity.

DESIGN DATA

FIGURE 1 – 470 MHz TEST CIRCUIT



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All Capacitance Values in pF Except As Noted.

FIGURE 2 – POWER OUTPUT versus POWER INPUT

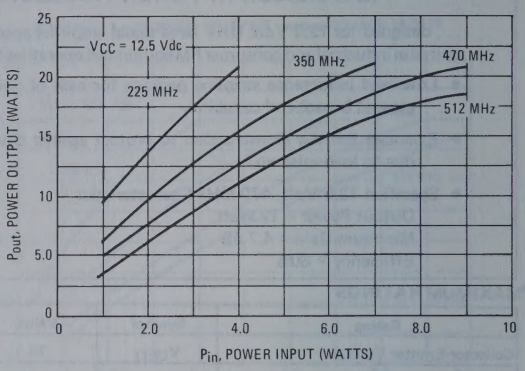


FIGURE 3 – POWER OUTPUT versus FREQUENCY

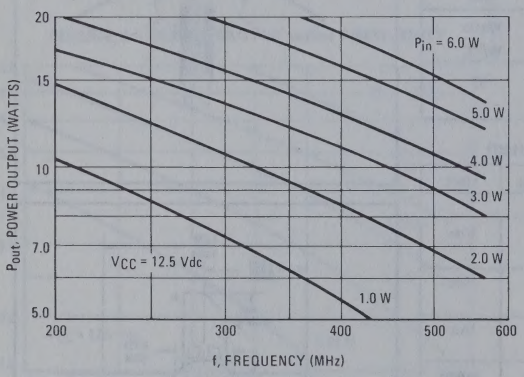


FIGURE 4 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

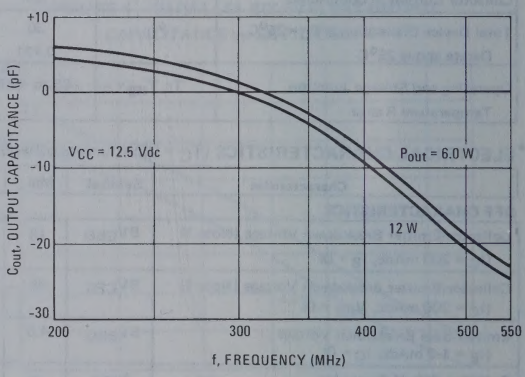


FIGURE 5 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

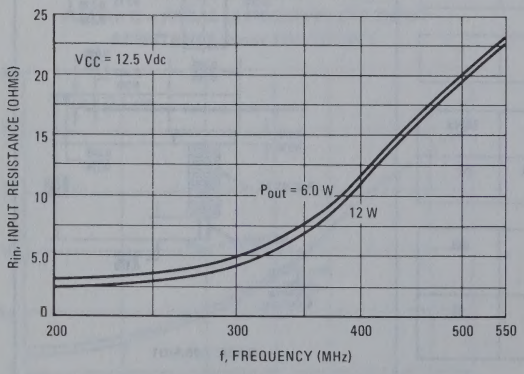
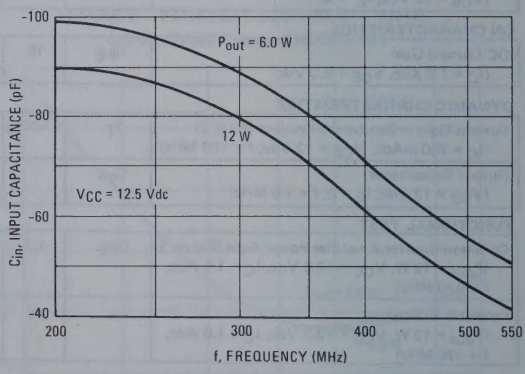


FIGURE 6 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



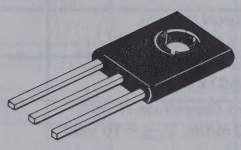
2N5655 (SILICON)
2N5656
2N5657

PLASTIC NPN SILICON HIGH-VOLTAGE POWER TRANSISTORS

. . . designed for use in line-operated equipment such as audio output amplifiers; low-current, high-voltage converters; and AC line relays.

- Excellent DC Current Gain – h_{FE} = 30-250 @ I_C = 50 mAdc
- Current-Gain–Bandwidth Product – f_T = 10 MHz (Min) @ I_C = 100 mAdc
- Packaged in Thermopad† Case for Low Cost

0.5 AMPERE POWER TRANSISTORS
NPN SILICON
250-300-350 VOLTS
20 WATTS



*MAXIMUM RATINGS

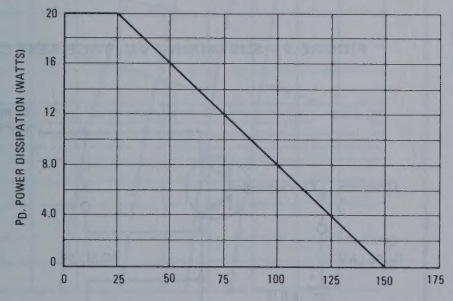
Rating	Symbol	2N5655	2N5656	2N5657	Unit
Collector-Emitter Voltage	V_{CEO}	250	300	350	Vdc
Collector-Base Voltage	V_{CB}	275	325	375	Vdc
Emitter-Base Voltage	V_{EB}	6.0			Vdc
Collector Current – Continuous Peak	I_C	0.5 1.0			Adc
Base Current	I_B	0.25			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.16			Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +150			°C

*THERMAL CHARACTERISTICS

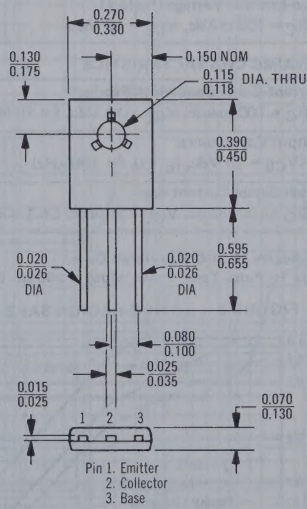
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.25	°C/W

*Indicates JEDEC Registered Data.

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 2. Both limits are applicable and must be observed.



Pin 1. Emitter
2. Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

2N5655, 2N5656, 2N5657 (continued)

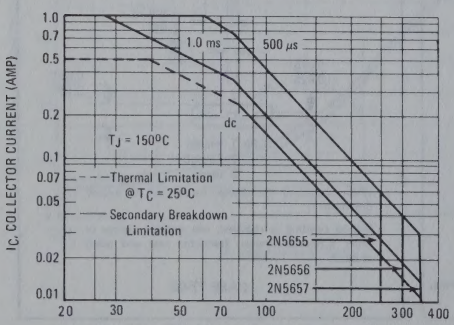
***ELECTRICAL CHARACTERISTICS** (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 100 mAdc (inductive), L = 50 mH)	2N5655	$V_{CEO(sus)}$	250	–	Vdc
	2N5656		300	–	
	2N5657		350	–	
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	2N5655	BV_{CEO}	250	–	Vdc
	2N5656		300	–	
	2N5657		350	–	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 150 Vdc, I_B = 0)	2N5655		–	0.1	
(V_{CE} = 200 Vdc, I_B = 0)	2N5656		–	0.1	
(V_{CE} = 250 Vdc, I_B = 0)	2N5657		–	0.1	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5655		–	0.1	
(V_{CE} = 300 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5656		–	0.1	
(V_{CE} = 350 Vdc, $V_{EB(off)}$ = 1.5 Vdc)	2N5657		–	0.1	
(V_{CE} = 150 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5655		–	1.0	
(V_{CE} = 200 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5656		–	1.0	
(V_{CE} = 250 Vdc, $V_{EB(off)}$ = 1.5 Vdc, T_C = 100°C)	2N5657		–	1.0	
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 275 Vdc, I_E = 0)	2N5655		–	10	
(V_{CB} = 325 Vdc, I_E = 0)	2N5656		–	10	
(V_{CB} = 375 Vdc, I_E = 0)	2N5657		–	10	
Emitter Cutoff Current (V_{EB} = 6.0 Vdc, I_C = 0)		I_{EBO}	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (Note 1)		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)			30	250	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)			25	–	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)			15	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)			5.0	–	
Collector-Emitter Saturation Voltage (Note 1)		$V_{CE(sat)}$			Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			–	1.0	
(I_C = 250 mAdc, I_B = 25 mAdc)			–	2.5	
Base-Emitter Voltage (Note 1) (I_C = 100 mAdc, V_{CE} = 10 Vdc)		V_{BE}	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)		f_T	10	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	25	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	20	–	–

*Indicates JEDEC Registered Data.

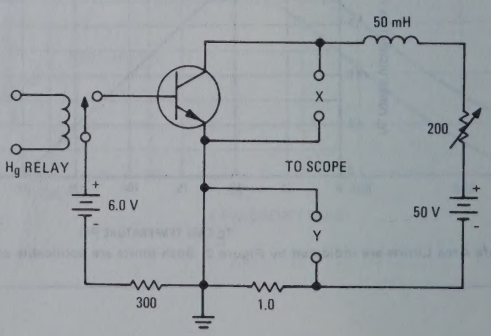
Note 1: Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – ACTIVE-REGION SAFE OPERATING AREA



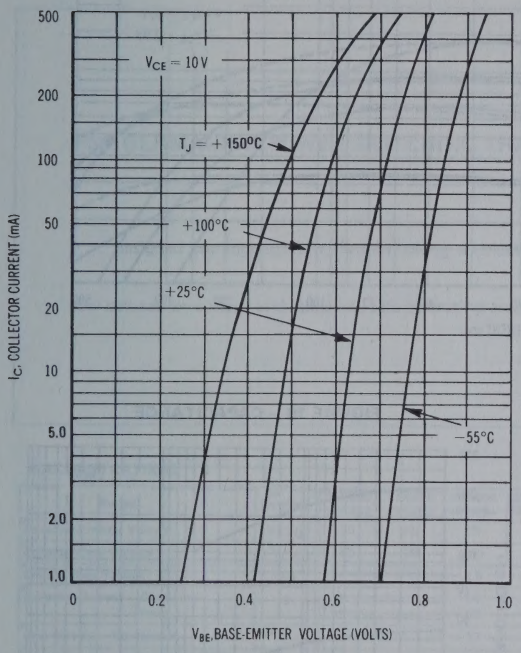
The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

FIGURE 3 – SUSTAINING VOLTAGE TEST CIRCUIT



LARGE SIGNAL CHARACTERISTICS

FIGURE 4 – TRANSCONDUCTANCE



CUT-OFF CHARACTERISTICS

FIGURE 5 – TRANSCONDUCTANCE

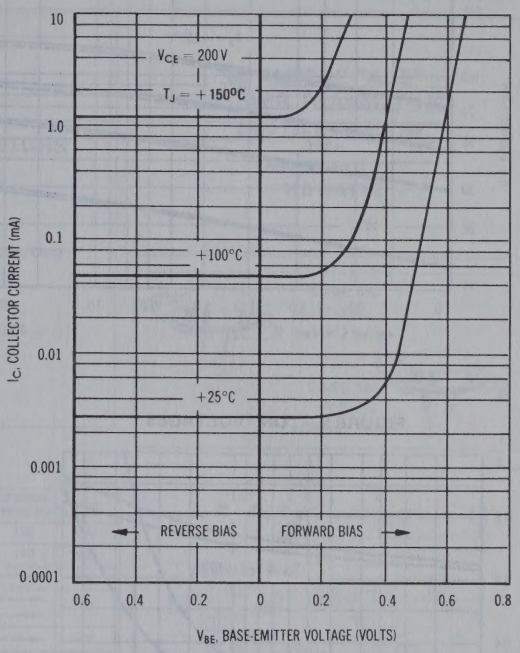


FIGURE 6 – INPUT ADMITTANCE

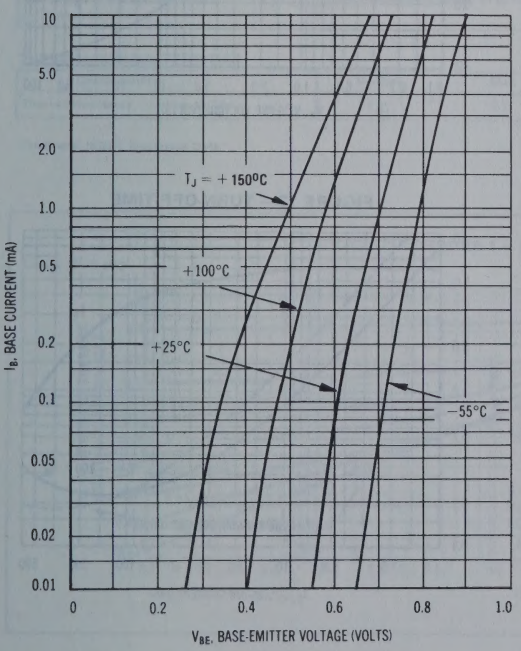


FIGURE 7 – EFFECT OF BASE-EMITTER RESISTANCE

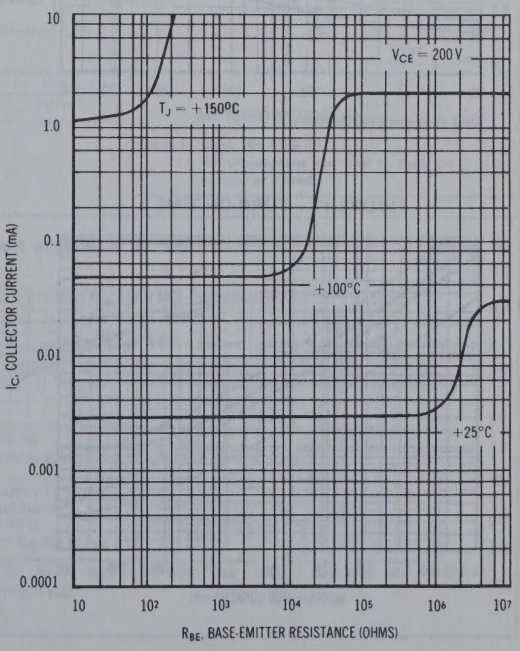


FIGURE 8 – CURRENT GAIN

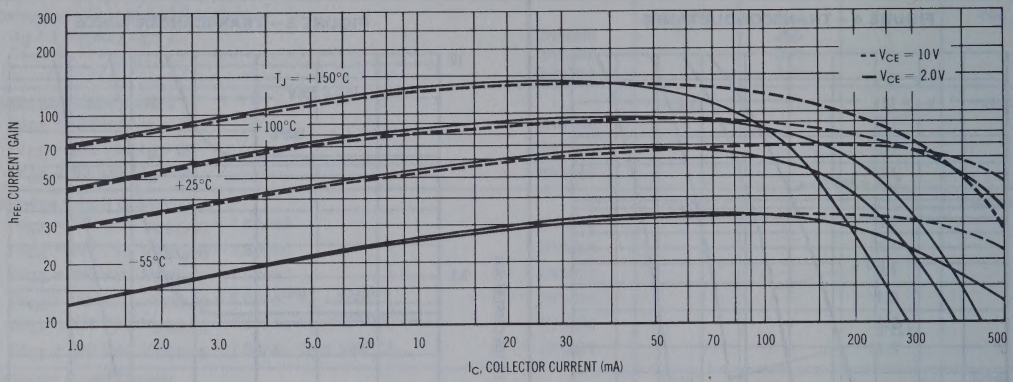


FIGURE 9 – "ON" VOLTAGES

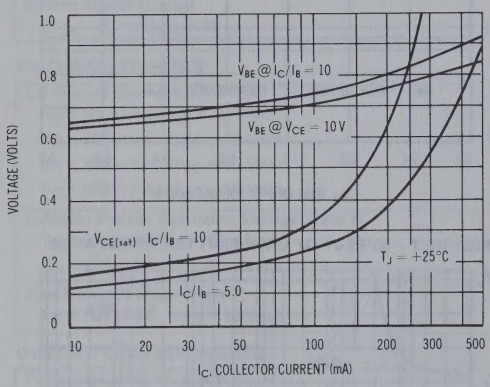


FIGURE 10 – CAPACITANCE

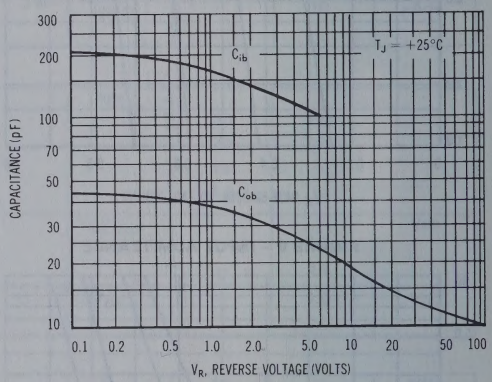


FIGURE 11 – TURN-ON TIME

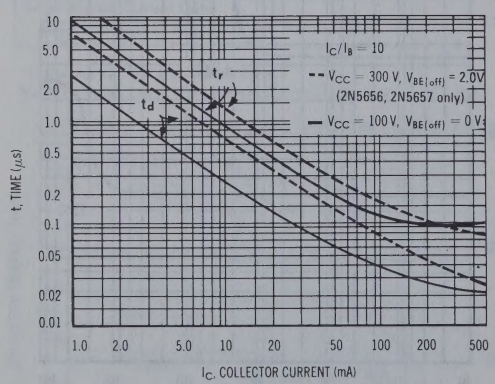
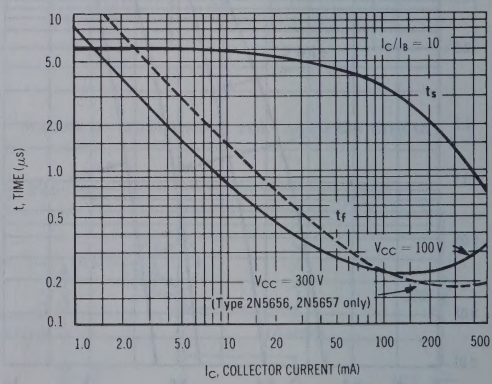


FIGURE 12 – TURN-OFF TIME

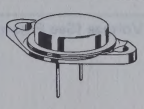


2N5692 thru 2N5696 (GERMANIUM)
MP5692 thru MP5696

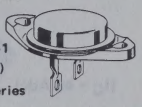
PNP GERMANIUM POWER SWITCHING TRANSISTORS

. . . designed for high-current, fast-switching applications requiring low saturation voltage and excellent safe operating area.

40 AMPERE "ADE" POWER TRANSISTORS
PNP GERMANIUM
50–140 VOLTS
120 WATTS



CASE 3A
(TO-3)
2N5692 Series



CASE 161
(TO-41)
MP5692 Series

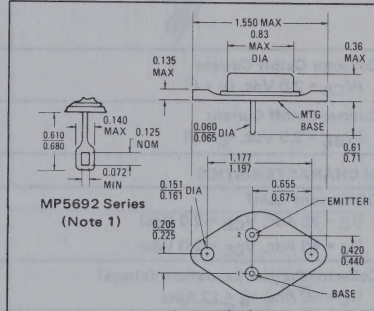
MAXIMUM RATINGS

Rating	Symbol	2N5692 MP5692	2N5693 MP5693	2N5694 MP5694	2N5695 MP5695	2N5696 MP5696	Unit
*Collector-Emitter Voltage	V_{CEO}	30	60	80	100	120	Vdc
*Collector-Base Voltage	V_{CB}	50	80	100	120	140	Vdc
*Emitter-Base Voltage	V_{EB}	← 2.5 →					Vdc
*Collector Current — Continuous	I_C	← 40 →					Adc
— Peak		← 60 →					
*Base Current — Continuous	I_B	← 12 →					Adc
*Total Device Dissipation @ $T_C = 25^oC$	P_D	← 120 →					Watts
Derate above 25^oC		← 1.43 →					$W/^oC$
*Operating and Storage Junction Temperature Range	T_J, T_{stg}	← −65 to +110 →					^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
*Thermal Resistance, Junction to Case	θ_{JC}	0.7	$^oC/W$

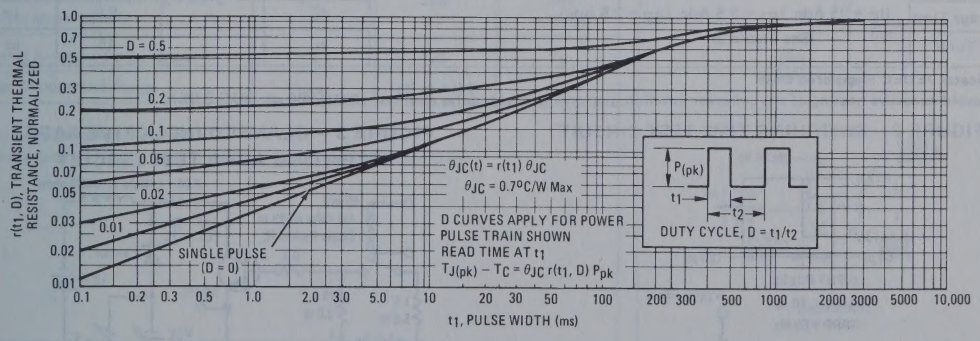
*Indicates JEDEC Registered Data.



CASE 3A
(TO-3)
Collector Connected to Case

Note 1. Case 161 (TO-41)
All dimensions identical to Case 3A (TO-3) except as noted.

FIGURE 1 — THERMAL RESPONSE



2N5692 thru 2N5696/MP5692 thru MP5696 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
* Collector-Emitter Breakdown Voltage (I_C = 0.1 Adc, I_B = 0)		BV_{CEO}			Vdc
	2N5692 MP5692		30	–	
	2N5693 MP5693		60	–	
	2N5694 MP5694		80	–	
	2N5695 MP5695		100	–	
	2N5696 MP5696		120	–	
* Collector Cutoff Current		I_{CEX1}			mAdc
(V_{CE} = 50 Vdc) $V_{BE(off)}$ = 0.2 Vdc	2N5692 MP5692		–	10	
(V_{CE} = 80 Vdc)	2N5693 MP5693		–	10	
(V_{CE} = 100 Vdc) For	2N5694 MP5694		–	10	
(V_{CE} = 120 Vdc) All Types	2N5695 MP5695		–	10	
(V_{CE} = 140 Vdc)	2N5696 MP5696		–	10	
* Collector Cutoff Current		I_{CEX2}(1)			mAdc
(V_{CE} = 50 Vdc) $V_{BE(off)}$ = 0.2 Vdc, T_C = +85°C	2N5692 MP5692		–	30	
(V_{CE} = 80 Vdc) For	2N5693 MP5693		–	30	
(V_{CE} = 100 Vdc)	2N5694 MP5694		–	30	
(V_{CE} = 120 Vdc) All Types	2N5695 MP5695		–	30	
(V_{CE} = 140 Vdc)	2N5696 MP5696		–	30	
* Collector-Emitter Sustaining Voltage (See Figure 3)		$V_{CEX(sus)}$			Vdc
(I_C = 10 Adc)	2N5692 MP5692		50	–	
	2N5693 MP5693		80	–	
	2N5694 MP5694		100	–	
	2N5695 MP5695		120	–	
	2N5696 MP5696		140	–	
(I_C = 40 Adc)	2N5692 MP5692		45	–	
	2N5693 MP5693		50	–	
	2N5694 MP5694		55	–	
	2N5695 MP5695		60	–	
	2N5696 MP5696		65	–	
* Collector Cutoff Current (V_{CB} = 2.0 Vdc, I_E = 0)		I_{CBO}	–	200	μAdc
* Emitter Cutoff Current (V_{BE} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	500	mAdc
ON CHARACTERISTICS					
* DC Current Gain†		h_{FE}(1)			–
(I_C = 25 Adc, V_{CE} = 2.0 Vdc)			20	65	
(I_C = 40 Adc, V_{CE} = 2.0 Vdc)			10	–	
* Collector-Emitter Saturation Voltage† (I_C = 60 Adc, I_B = 12 Adc)		$V_{CE(sat)}$(1)	–	0.75	Vdc
* Base-Emitter Saturation Voltage† (I_C = 60 Adc, I_B = 12 Adc)		$V_{BE(sat)}$(1)	–	1.2	Vdc
SMALL-SIGNAL CHARACTERISTICS					
* Current-Gain–Bandwidth Product (I_C = 5.0 Adc, V_{CE} = 5.0 Vdc, f = 100 kHz)		f_T	200	–	kHz
SWITCHING CHARACTERISTICS					
* Rise Time	(I_C = 25 Adc, I_{B1} = 2.5 Adc, I_{B2} = 2.5 Adc) (See Figure 2)	t_r	–	20	μs
* Storage Time		t_s	–	8.0	μs
* Fall Time		t_f	–	15	μs

*Indicates JEDEC Registered Data.

(1) To avoid excessive heating of the collector junction, perform test with pulse method. (PW ≤ 300 μs, DC ≤ 2.0%).

FIGURE 2 – SWITCHING TIME TEST CIRCUIT

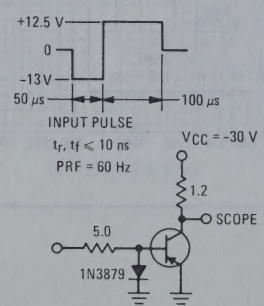
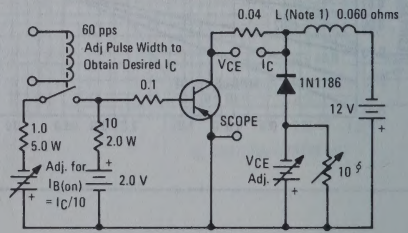


FIGURE 3 – CLAMPED INDUCTIVE SAFE OPERATING AREA TEST CIRCUIT



∮ Set to allow reverse surge current to by pass power supply. Not needed for power supply with low reverse impedance.

NOTE 1: L = 10 mH at I_C = 10 A
L = 0.25 mH at I_C = 40 A

2N5716 (SILICON)
2N5717
2N5718

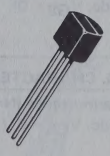
SILICON N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

Depletion Mode (Type A) Junction Field-Effect Transistors designed primarily for low-power audio amplifier applications.

- High DC Input Resistance
- Drain and Source Interchangeable
- Low Input Capacitance –
  C_{iss} = 5.0 pF (Max) @ V_{DS} = 15 Vdc
- Low Reverse Transfer Capacitance –
  C_{rss} = 1.5 pF (Max) @ V_{DS} = 15 Vdc
- Low Zero Gate Voltage Drain Current –
  I_{DSS} = 0.05 – 0.25 mAdc 2N5716
  0.2 – 1.0 mAdc 2N5717
  0.8 – 4.0 mAdc 2N5718

N-CHANNEL JUNCTION FIELD-EFFECT TRANSISTORS

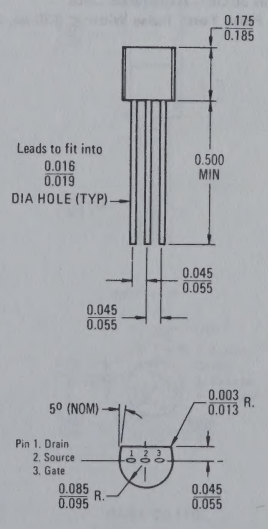
(Type A)



*MAXIMUM RATINGS

Rating	Symbol	Value	Unit
#Drain-Source Voltage	V_{DS}	40	Vdc
Drain-Gate Voltage	V_{DG}	40	Vdc
Reverse Gate-Source Voltage	V_{GSR}	-40	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
#Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*Indicates JEDEC Registered Data.
#Motorola Guarantees this Data in Addition to JEDEC Registered Data.



Case 29(5)
(TO-92)

***ELECTRICAL CHARACTERISTICS** (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	-40	–	Vdc
Gate-Source Cutoff Voltage (V_{DS} = 15 Vdc, I_D = 1.0 nAdc)	2N5716 2N5717 2N5718	$V_{GS(off)}$	-0.2 -0.5 -1.0	-3.0 -5.0 -8.0	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0) (V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 100°C)		I_{GSS}	– –	1.0 200	nAdc
ON CHARACTERISTICS					
Zero-Gate Voltage Drain Current (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0)	2N5716 2N5717 2N5718	I_{DSS}	0.05 0.2 0.8	0.25 1.0 4.0	mAdc
SMALL-SIGNAL CHARACTERISTICS					
Forward Transadmittance (Note 1) (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)	2N5716 2N5717 2N5718	$\|y_{fs}\|$	200 400 500	1000 1600 2000	μmhos
Output Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 kHz)		$\|y_{os}\|$	–	25	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{iss}	–	5.0	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1.0 MHz)		C_{rss}	–	1.5	pF

*Indicates JEDEC Registered Data.

Note 1: Pulse Test: Pulse Width ≤ 630 μs, Duty Cycle ≤ 10%.

2N5829 (SILICON)

PNP SILICON SMALL-SIGNAL RF TRANSISTOR

. . . designed for high-gain, low-noise amplifier, oscillator, and mixer applications.

- Low Noise Figure – NF = 2.5 dB (Max) @ f = 450 MHz
- High Power Gain – G_{pe} = 17 dB (Min) @ f = 450 MHz
- High Gain-Bandwidth Product – f_T = 1600 MHz (Typ)
- Low Collector-Base Capacitance – C_{cb} = 0.4 pF (Typ)

PNP SILICON RF AMPLIFIER TRANSISTOR

*MAXIMUM RATINGS

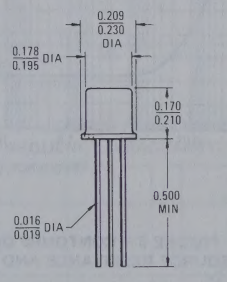
Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	30	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 1.14	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

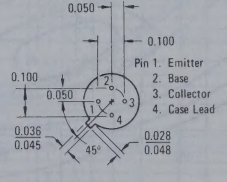
*ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	30	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	–	–	0.1	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	40	150	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (1) (I_E = 2.0 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	1200	1600	–	MHz
Collector-Base Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.4	0.8	pF
Small-Signal Current Gain (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	h_{fe}	20	–	200	–
Collector-Base Time Constant (I_E = 2.0 mAdc, V_{CB} = 10 Vdc, f = 63.6 MHz)	$r_b'C_C$	1.0	–	8.0	ps
Noise Figure (Figure 1) (I_C = 2.0 mAdc, V_{CE} = 10 Vdc, f = 450 MHz)	NF	–	2.3	2.5	dB
FUNCTIONAL TESTS					
Common-Emitter Amplifier Power Gain (V_{CE} = 10 Vdc, I_C = 2.0 mAdc, f = 450 MHz)	G_{pe}	17	–	–	dB

*Indicates JEDEC Registered Data.

(1) f_T is defined as the frequency at which h_{fe} extrapolates to unity.





CASE 20 (10)
TO-72 PACKAGE

ACTIVE ELEMENTS ISOLATED FROM CASE

RF PERFORMANCE DATA

FIGURE 1 – NOISE FIGURE AND POWER GAIN TEST CIRCUIT

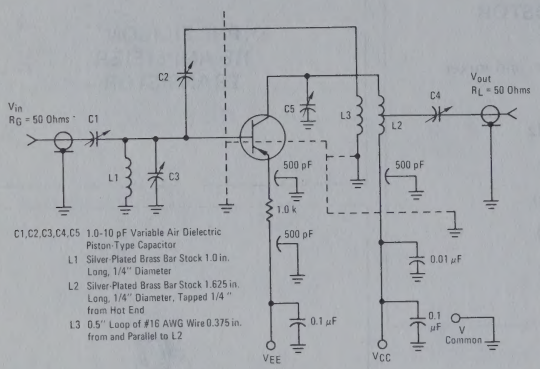


FIGURE 2 – UNILATERALIZED POWER GAIN versus FREQUENCY

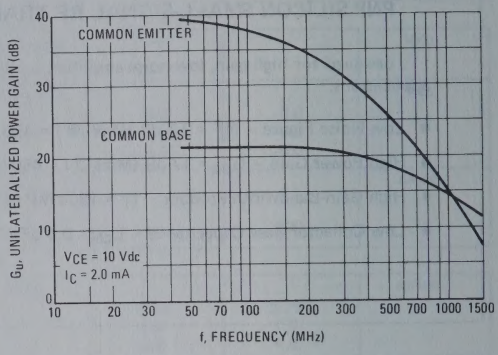


FIGURE 3 – NOISE FIGURE versus FREQUENCY

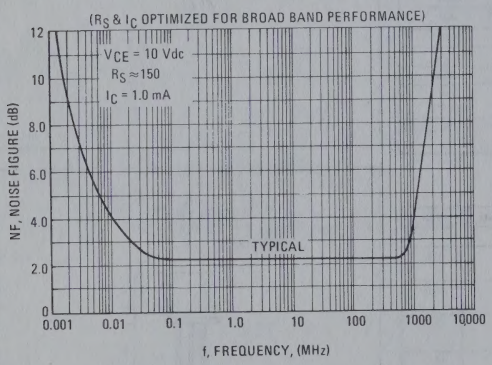


FIGURE 4 – NOISE FIGURE AND POWER GAIN versus COLLECTOR CURRENT

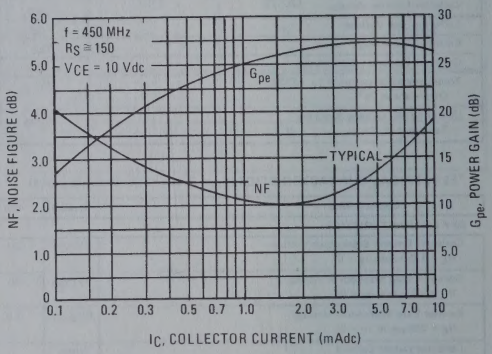


FIGURE 5 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT

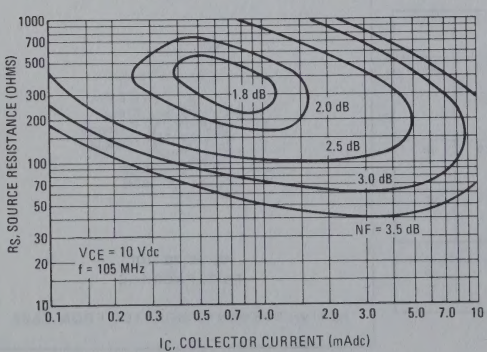
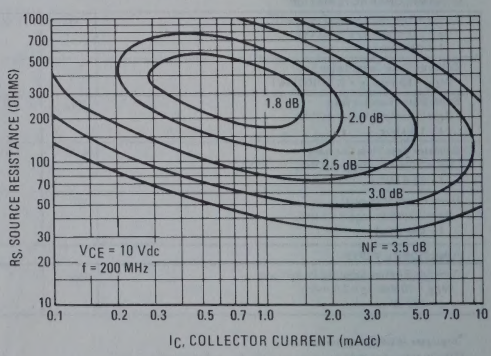


FIGURE 6 – CONTOURS OF NOISE FIGURE versus SOURCE RESISTANCE AND COLLECTOR CURRENT



COMMON EMITTER CIRCUIT DESIGN DATA

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 7 – TRANSDUCER GAIN versus FREQUENCY

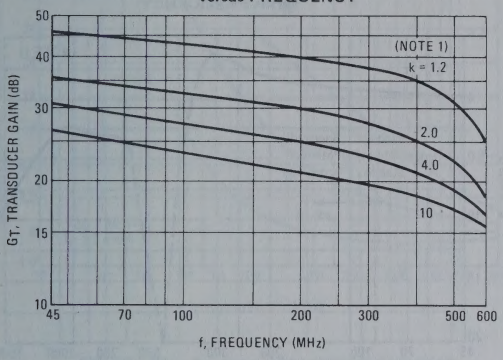


FIGURE 8 – LINVILL STABILITY FACTOR versus FREQUENCY

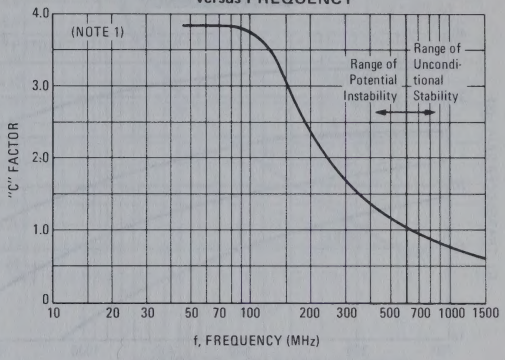


FIGURE 9 – LOAD ADMITTANCE versus FREQUENCY (REAL)

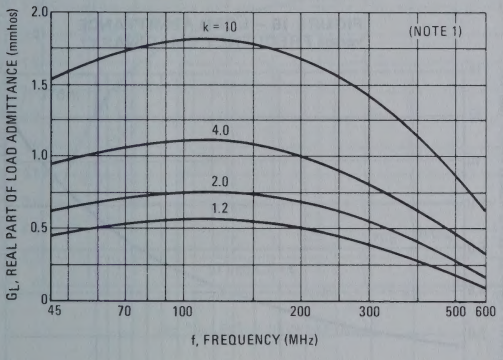


FIGURE 10 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

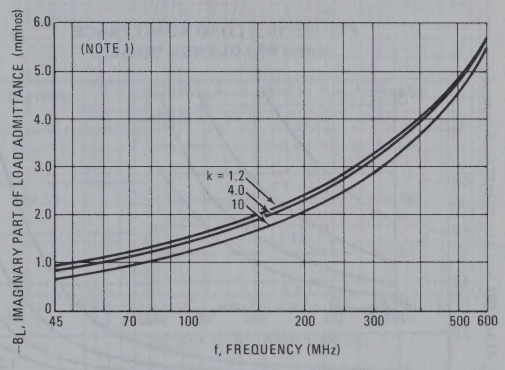


FIGURE 11 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

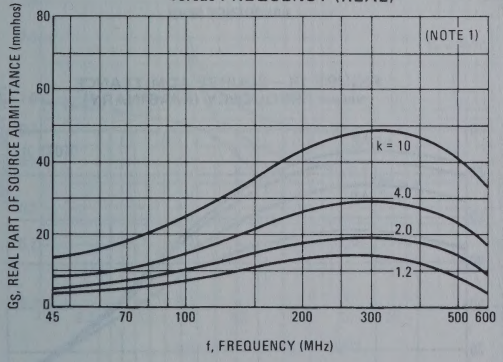
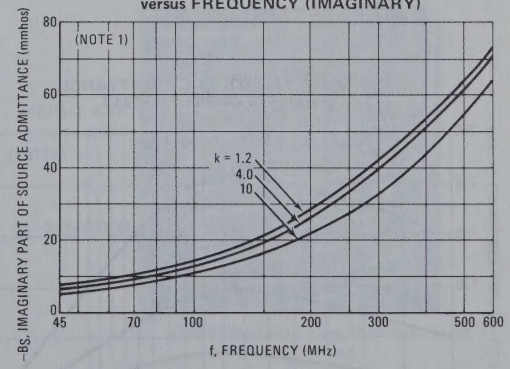


FIGURE 12 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)



NOTE 1

Figures 7 through 18 are included to assist the circuit designer in determining the stability of his particular circuit. Two stability criteria are given in these figures.

The Linvill "C" factor* is a measure of transistor stability when the input and output are terminated in the worst-case (open circuit) condition. When "C" is less than 1.0, the circuit is unconditionally stable. When "C" is greater than 1.0, the circuit is potentially unstable.

The Stern "K" factor† has been defined to determine the stability of a practical amplifier terminated in finite load and source admittances. If "K" is greater than 1.0, the circuit will be stable. If less than 1.0, the circuit will be unstable. For further details, see Application Note AN-215.

* "Transistors and Active Circuits," Linvill and Gibbons, McGraw-Hill, 1961.

† "Stability and Power Gain of Tuned Transistor Amplifiers," Arthur P. Stern, Proc. I.R.E., March 1967.

COMMON BASE CIRCUIT DESIGN DATA

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

FIGURE 13 – TRANSDUCER GAIN versus FREQUENCY

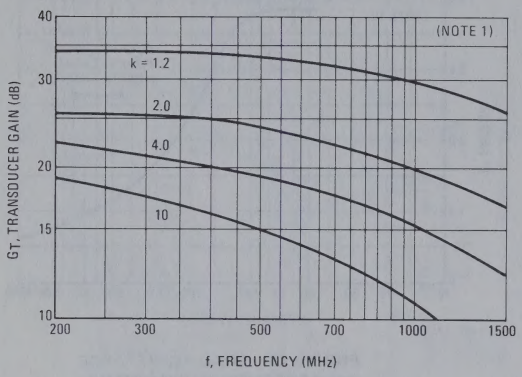


FIGURE 14 – LINVILL STABILITY FACTOR versus FREQUENCY

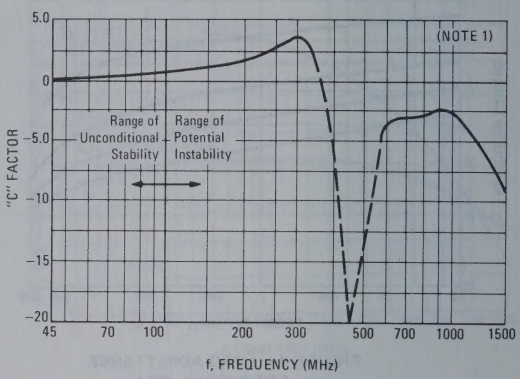


FIGURE 15 – LOAD ADMITTANCE versus FREQUENCY (REAL)

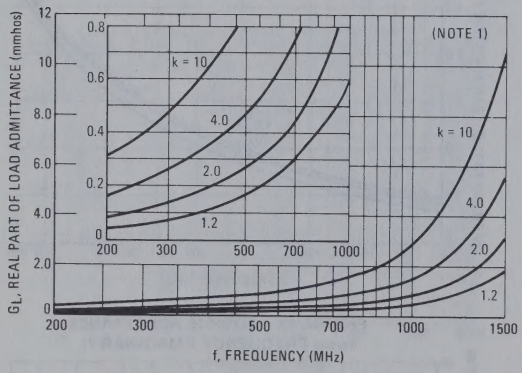


FIGURE 16 – LOAD ADMITTANCE versus FREQUENCY (IMAGINARY)

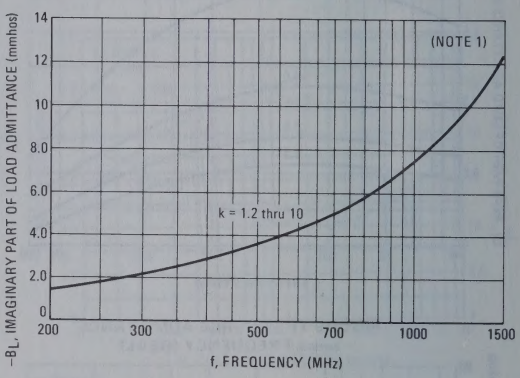


FIGURE 17 – SOURCE ADMITTANCE versus FREQUENCY (REAL)

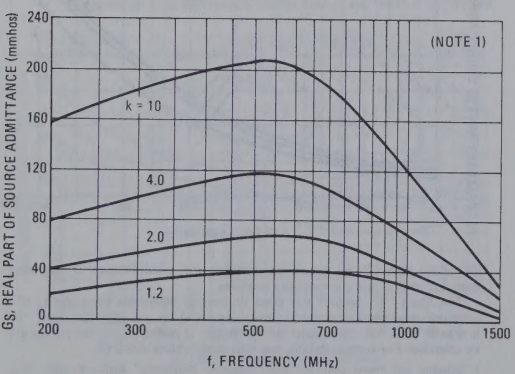


FIGURE 18 – SOURCE ADMITTANCE versus FREQUENCY (IMAGINARY)

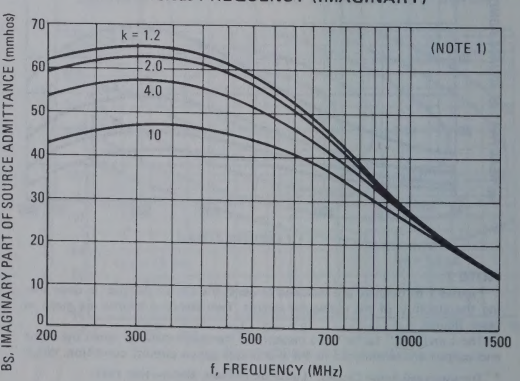


FIGURE 19 – SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

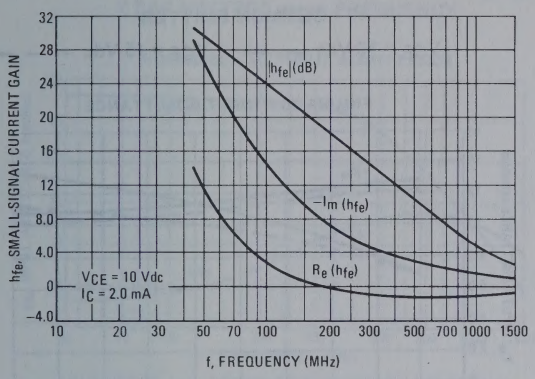


FIGURE 20 – POLAR h_{fe}

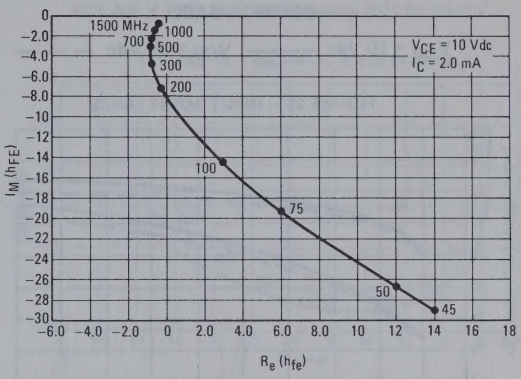


FIGURE 21 – f_T versus COLLECTOR CURRENT

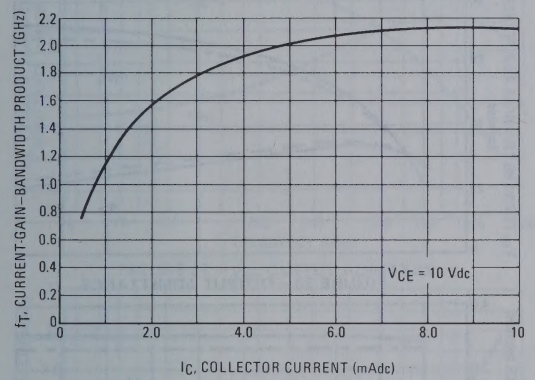


FIGURE 22 – DC CURRENT GAIN

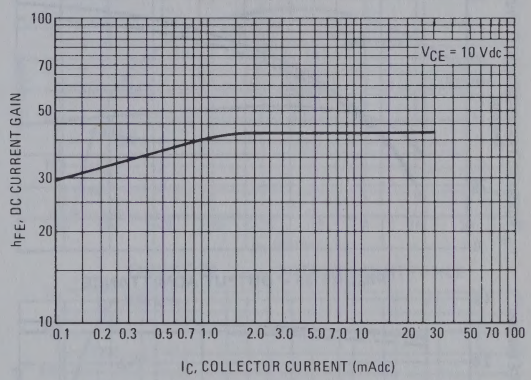


FIGURE 23 – CAPACITANCE

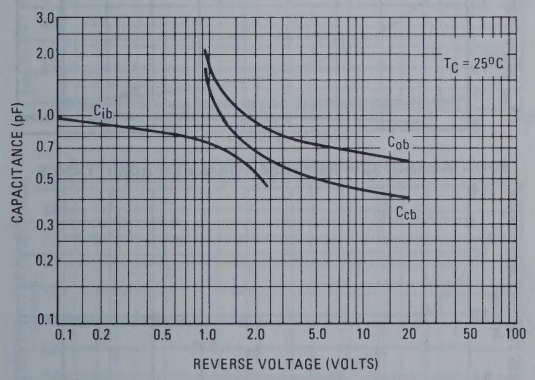
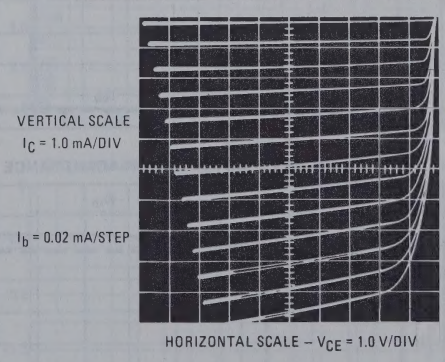
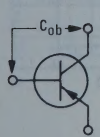
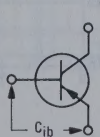


FIGURE 24 – COLLECTOR CHARACTERISTICS

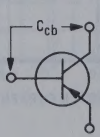




Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is open.



Apply reverse bias between emitter and base and measure capacitance between these terminals. Collector is open.



Apply reverse bias between collector and base and measure capacitance between these terminals. Emitter is guarded.

Y PARAMETERS versus CURRENT

(f = 450 MHz)

COMMON BASE

V_{CB} = 10 Vdc ——— V_{CB} = 15 Vdc — — —

FIGURE 25 – INPUT ADMITTANCE

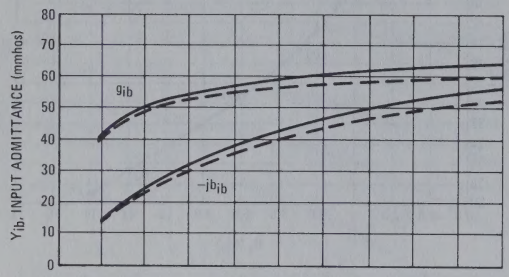


FIGURE 27 – FORWARD TRANSFER ADMITTANCE

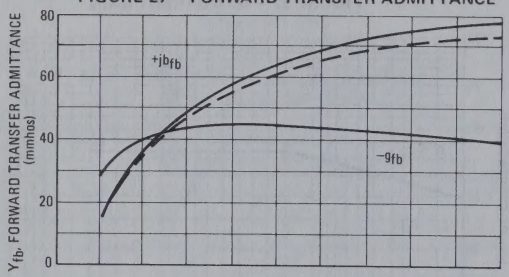


FIGURE 29 – OUTPUT ADMITTANCE

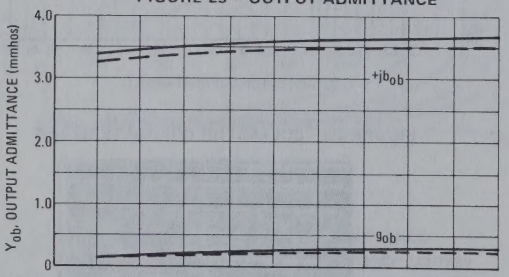
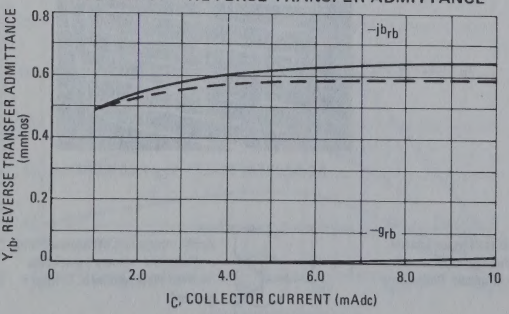


FIGURE 31 – REVERSE TRANSFER ADMITTANCE



COMMON EMITTER

V_{CE} = 10 Vdc ——— V_{CE} = 15 Vdc — — —

FIGURE 26 – INPUT ADMITTANCE

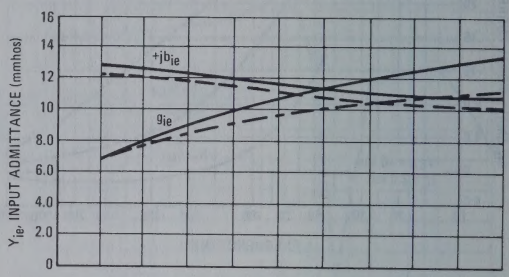


FIGURE 28 – FORWARD TRANSFER ADMITTANCE

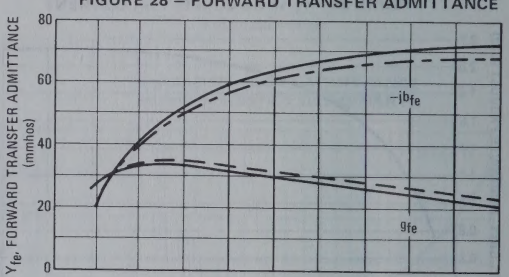


FIGURE 30 – OUTPUT ADMITTANCE

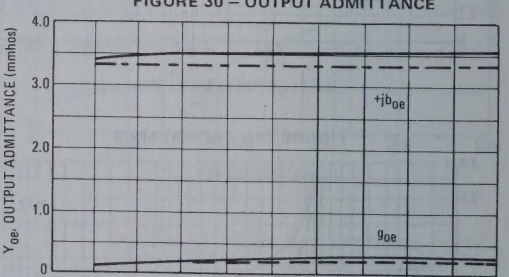
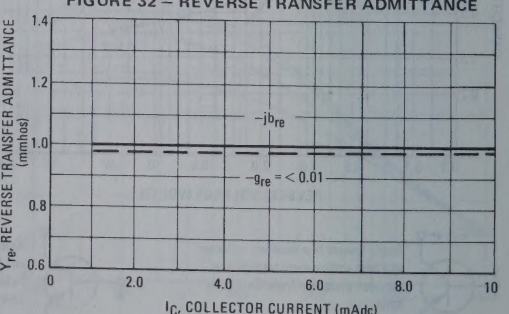


FIGURE 32 – REVERSE TRANSFER ADMITTANCE



COMMON BASE Y PARAMETER VARIATIONS

(V_{CB} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 33 – y_{ib} INPUT ADMITTANCE

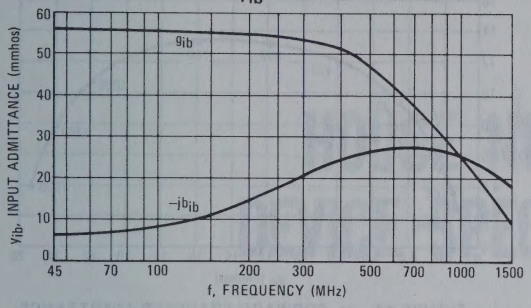


FIGURE 35 – y_{fb} FORWARD TRANSFER ADMITTANCE

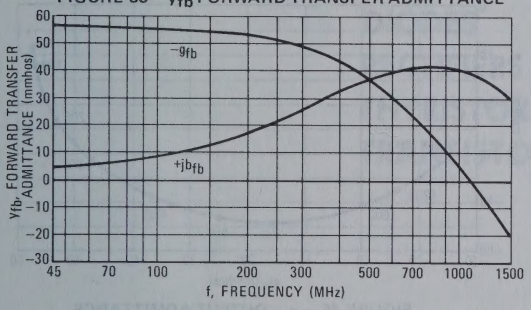


FIGURE 37 – y_{ob} OUTPUT ADMITTANCE

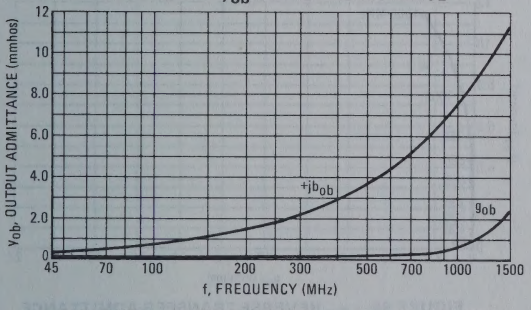
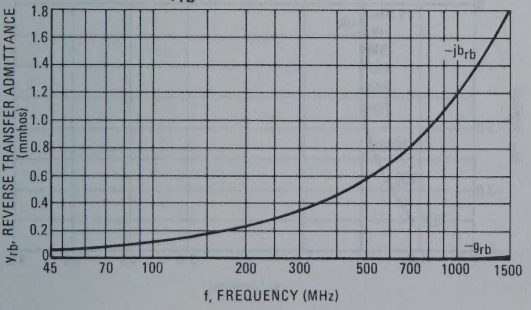


FIGURE 39 – y_{rb} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 34 – y_{ib} INPUT ADMITTANCE

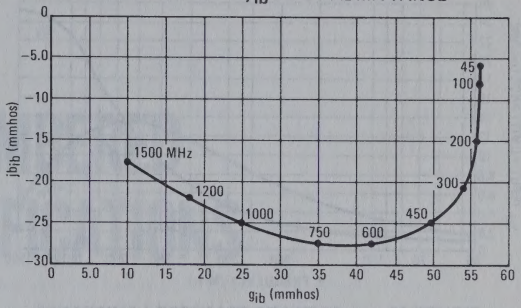


FIGURE 36 – y_{fb} FORWARD TRANSFER ADMITTANCE

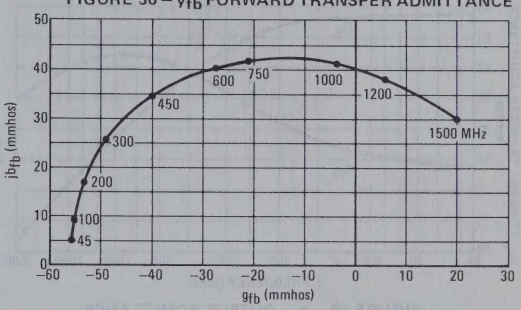


FIGURE 38 – y_{ob} OUTPUT ADMITTANCE

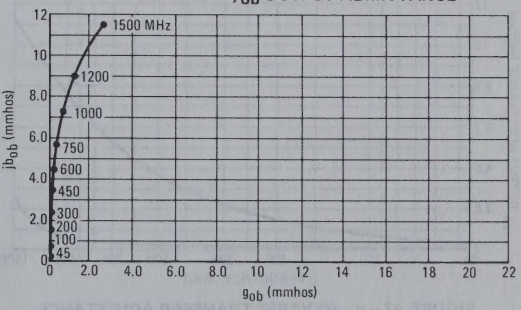
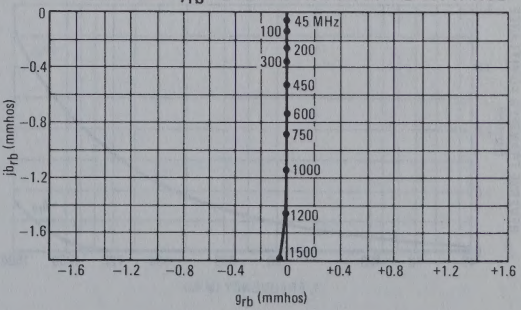


FIGURE 40 – y_{rb} REVERSE TRANSFER ADMITTANCE



COMMON EMITTER Y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 2.0 mAdc)

Y PARAMETERS versus FREQUENCY

FIGURE 41 – y_{ie} INPUT ADMITTANCE

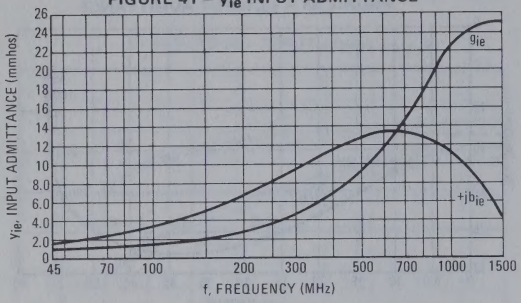


FIGURE 43 – y_{fe} FORWARD TRANSFER ADMITTANCE

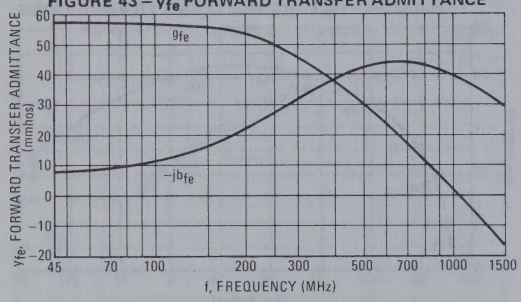


FIGURE 45 – y_{oe} OUTPUT ADMITTANCE

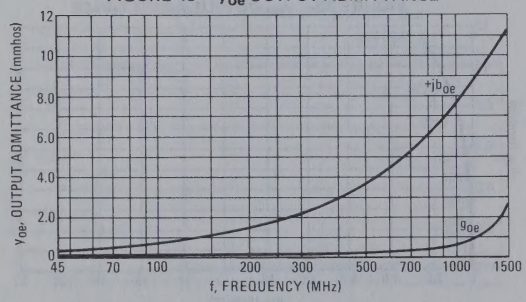
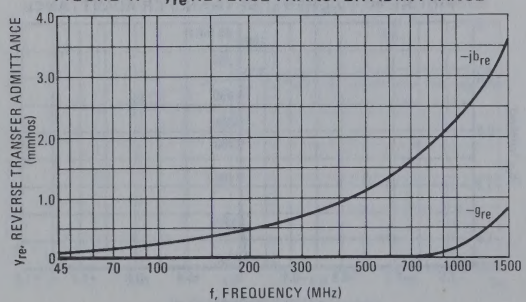


FIGURE 47 – y_{re} REVERSE TRANSFER ADMITTANCE



POLAR Y PARAMETERS versus FREQUENCY

FIGURE 42 – y_{ie} INPUT ADMITTANCE

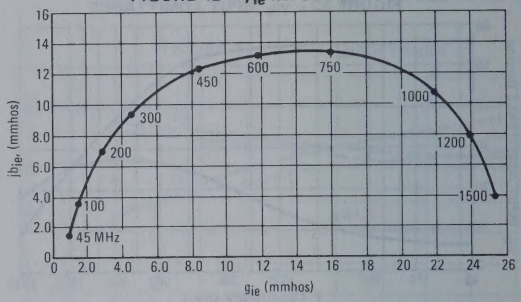


FIGURE 44 – y_{fe} FORWARD TRANSFER ADMITTANCE

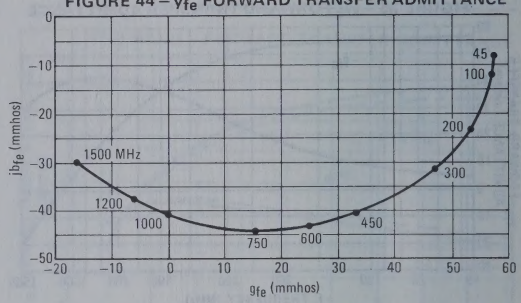


FIGURE 46 – y_{oe} OUTPUT ADMITTANCE

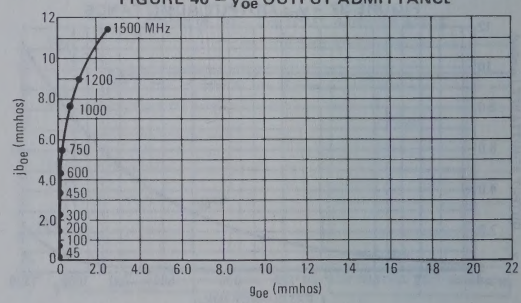
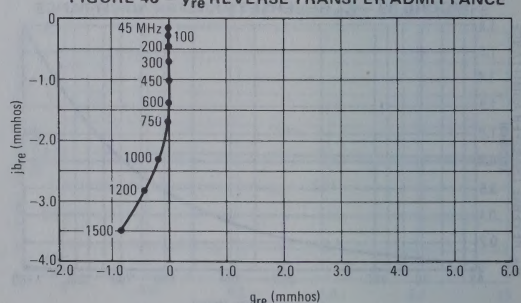


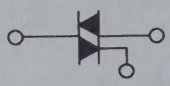
FIGURE 48 – y_{re} REVERSE TRANSFER ADMITTANCE



HOUSE NUMBERED DEVICE SPECIFICATIONS

DIODES
RECTIFIERS
THYRISTORS
TRANSISTORS

MAC35-1 thru MAC35-7 (SILICON)
MAC36-1 thru MAC36-7



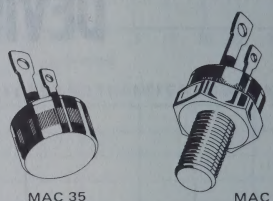
TRIAC
(THYRISTORS)

25 AMPERES RMS
25 thru 500 VOLTS

SILICON BIDIRECTIONAL THYRISTORS

. . . designed primarily for industrial and military applications for the control of ac loads in applications such as light dimmers, power supplies, heating controls, motor controls, welding equipment and power switching systems; or wherever full-wave, silicon gate controlled solid-state devices are needed.

- 25 Amperes RMS @ T_C = 67°C
- Low On-State Voltage — 1.5 Volts Maximum
- All-Diffused Junctions for Greater Uniformity

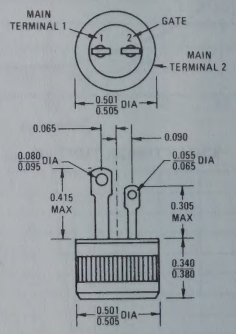


MAXIMUM RATINGS

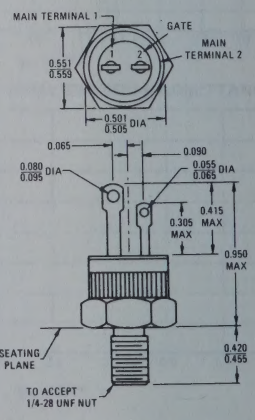
Rating	Symbol	Value	Unit
Repetitive Peak Off-State Voltage (1) (T_J = 110°C) MAC35 MAC36 −1	V_{DRM}	25	Volts
−2		50	
−3		100	
−4		200	
−5		300	
−6		400	
−7		500	
On-State Current RMS	$I_{T(RMS)}$	25	Amp
Peak Surge Current (One Full cycle, 60 Hz, T_J = −40 to +110°C)	I_{TSM}	225	Amp
Circuit Fusing Considerations (T_J = −40 to +110°C, t = 1.0 to 8.3 ms)	I^2t	210	A^2s
Peak Gate Power (2)	P_{GM}	5.0	Watts
Average Gate Power	$P_{G(AV)}$	0.5	Watt
Peak Gate Current (2)	I_{GM}	2.0	Amp
Operating Junction Temperature Range	T_J	−40 to +110	°C
Storage Temperature Range	T_{stg}	−40 to +150	°C
Stud Torque	—	30	in. lb.

(1) For either direction of blocking voltage. V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for open gate conditions. Thyristor devices shall not be tested with a constant current source for blocking capability such that the voltage applied exceeds the rated blocking voltage.

(2) T_J = 110°C, 1.0 second maximum duration; 5.0% duty cycle, I_{TM} = 10 Amp.



CASE 174 (3) MAC 35



CASE 175 (3) MAC 36

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Blocking Current (Either Direction) Rated V_{DRM} @ T_J = 110°C	I_{DRM}	–	–	4.0	mA
On-State Voltage (Either Direction) I_{TM} = 35 A Peak	V_{TM}	–	1.3	1.5	Volts
Gate Trigger Current, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms					
MT2(+)G(+); MT2(–)G(–)	I_{GT}	–	20	75	mA
MT2(+)G(–); MT2(–)G(+)	I_{GT}	–	30	100	mA
Gate Trigger Voltage, Continuous dc (1) Main Terminal Voltage = 7.0 Vdc, R_L = 47 ohms					
MT2(+)G(+); MT2(–)G(–)	V_{GT}	–	1.0	3.0	Volts
MT2(+) G(–); MT2(–)G(+)	V_{GT}	–	1.2	3.0	Volts
Gate Trigger Voltage, Continuous dc – All Modes Main Terminal Voltage = Rated V_{DRM}, R_L = 100 ohms, T_J = 110°C	V_{GD}	0.2	–	–	Volt
Holding Current (Either Direction) Main Terminal Voltage = 7.0 Vdc, Gate Open, Initiating Current = 150 mA	I_H	–	10	75	mA
Turn-On Time I_{TM} = 25 Adc, I_{GT} = 200 mA	t_{on}	–	1.0	–	μs
Critical Forward Voltage Application Rate (Exponential Rise of Voltage) @ V_{DRM}, T_J = 110°C, Gate Open	dv/dt	–	100	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–	–	1.0	°C/W

(1) All voltage polarity reference to main terminal 1.

FIGURE 1 – MAXIMUM THERMAL RESPONSE

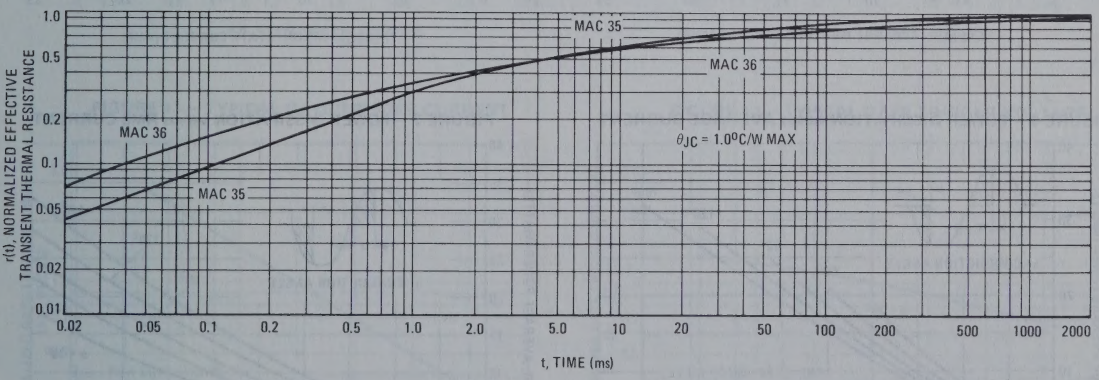


FIGURE 2 – AVERAGE CURRENT DERATING

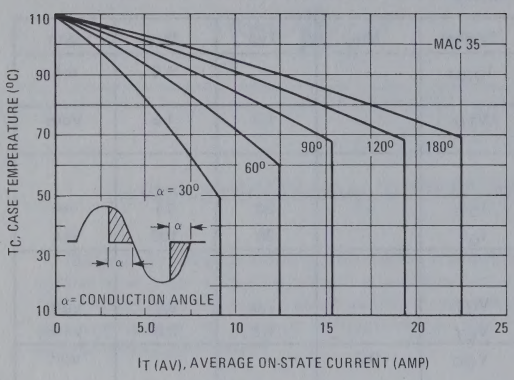


FIGURE 3 – RMS CURRENT DERATING

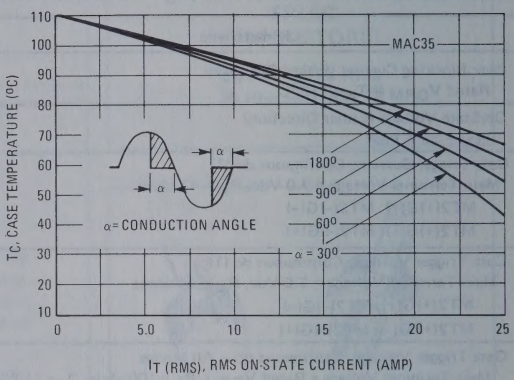


FIGURE 4 – AVERAGE CURRENT DERATING

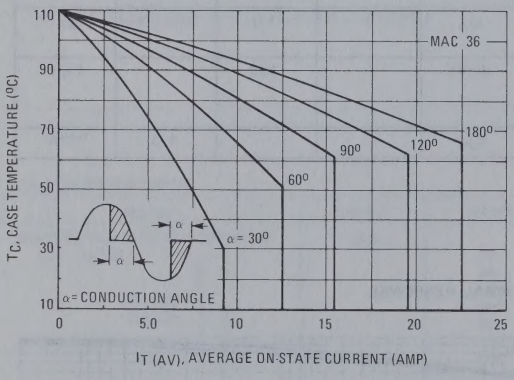


FIGURE 5 – RMS CURRENT DERATING

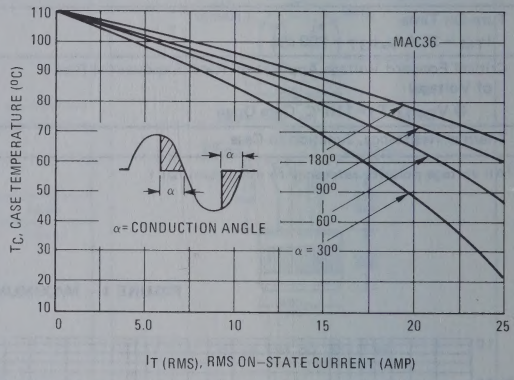


FIGURE 6 – POWER DISSIPATION versus AVERAGE CURRENT

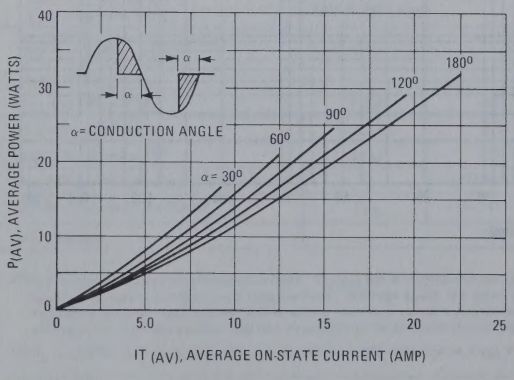


FIGURE 7 – POWER DISSIPATION versus RMS CURRENT

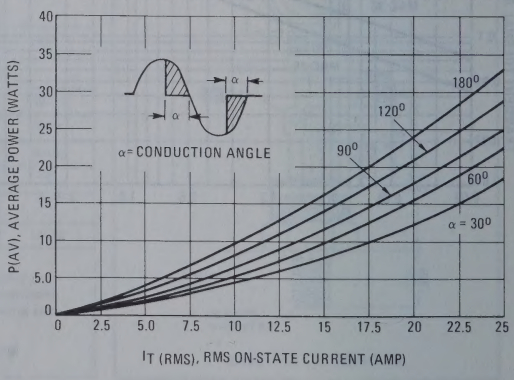


FIGURE 8 – MAXIMUM ON-STATE CHARACTERISTICS

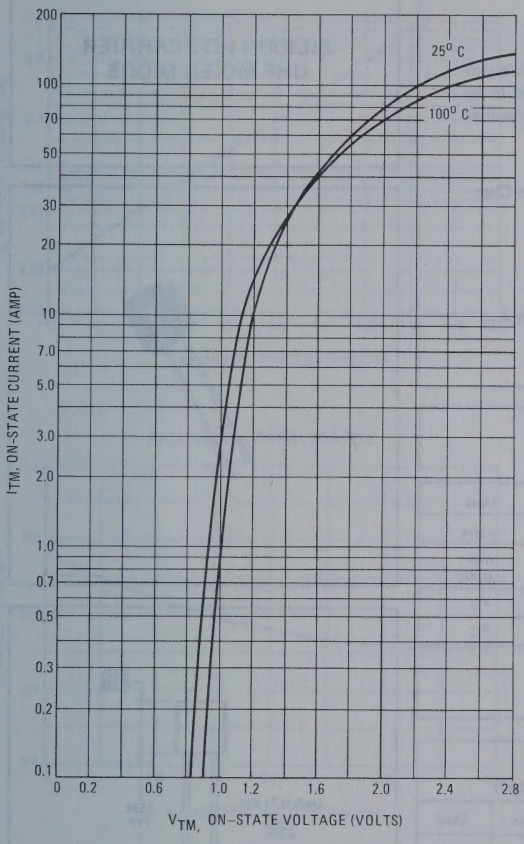


FIGURE 9 – MAXIMUM MULTI-CYCLE SURGE RATING

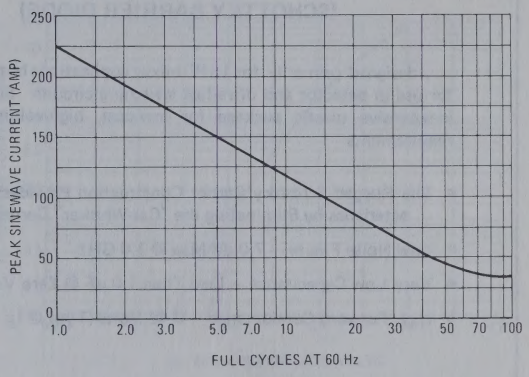


FIGURE 10 – TYPICAL HOLDING CURRENT

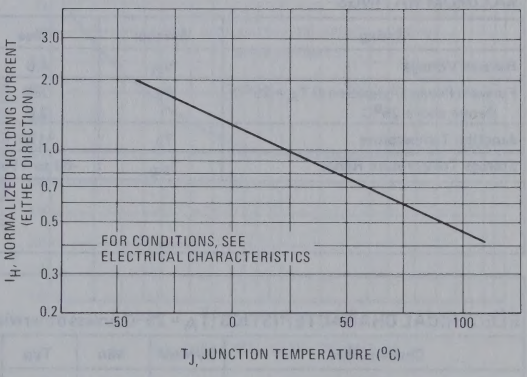


FIGURE 11 – TYPICAL GATE TRIGGER CURRENT

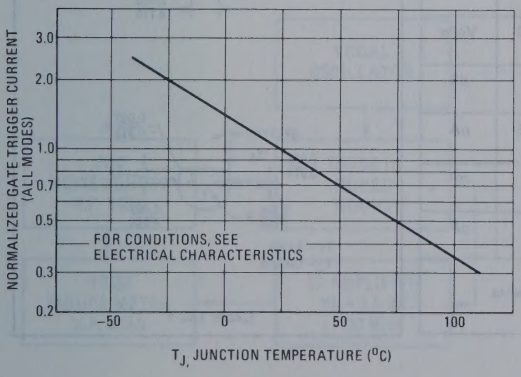
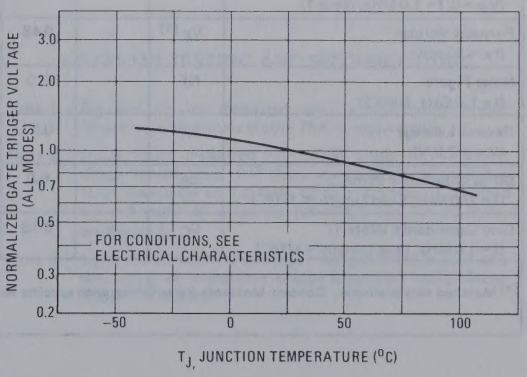


FIGURE 12 – TYPICAL GATE TRIGGER VOLTAGE



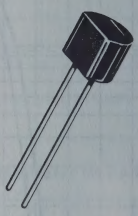
MBD101 (SILICON)

SILICON HOT-CARRIER DIODE (SCHOTTKY BARRIER DIODE)

. . . designed primarily for UHF mixer applications but suitable also for use in detector and ultra-fast switching circuits. Supplied in an inexpensive plastic package for low-cost, high-volume consumer requirements.

- The Rugged Schottky Barrier Construction Provides Stable Characteristics by Eliminating the "Cat-Whisker" Contact
- Low Noise Figure – 7.0 dB Max @ 1.0 GHz
- Very Low Capacitance – Less Than 1.0 pF @ Zero Volts
- High Forward Conductance – 0.48 Volts (Typ) @ I_F = 10 mA

SILICON HOT-CARRIER UHF MIXER DIODE



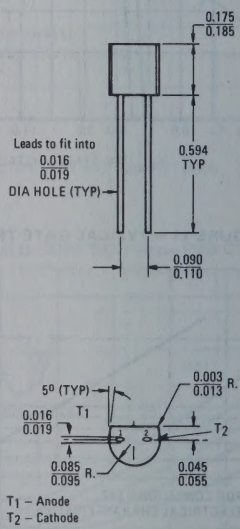
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Power Dissipation @ T_A = 25°C Derate above 25°C	P_F	280 2.8	mW mW/°C
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μA)	$V_{(BR)R}$	4.0	5.0	–	Volts
Diode Capacitance (V_R = 0, f = 1.0 MHz, Note 1)	C_T	–	0.88	1.0	pF
Forward Voltage (I_F = 10 mA)	V_F (1)	–	0.48	0.60	Volts
Noise Figure (f = 1.0 GHz, Note 2)	NF	–	6.0	7.0	dB
Reverse Leakage (V_R = 3.0 V)	I_R	–	0.02	0.25	μA
Series Inductance (Note 3) (f = 250 MHz, Lead Length ≈ 1/16")	L_S	–	6.0	–	nH
Case Capacitance (Note 1) (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	–	0.18	–	pF

(1) Matched sets available. Contact Motorola Sales Office with specific requirements.



CASE 182-1

TYPICAL CHARACTERISTICS
(T_A = 25°C unless noted)

FIGURE 1 – REVERSE LEAKAGE

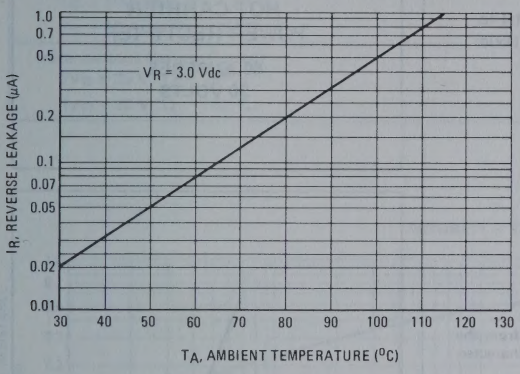


FIGURE 2 – FORWARD VOLTAGE

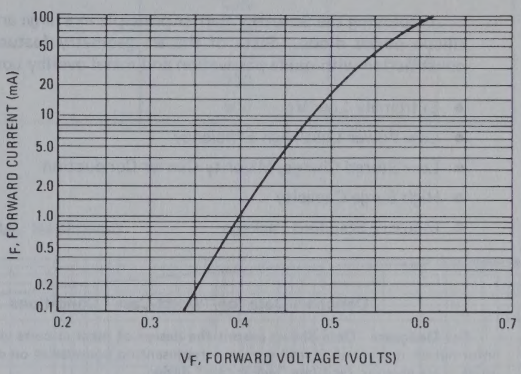


FIGURE 3 – CAPACITANCE

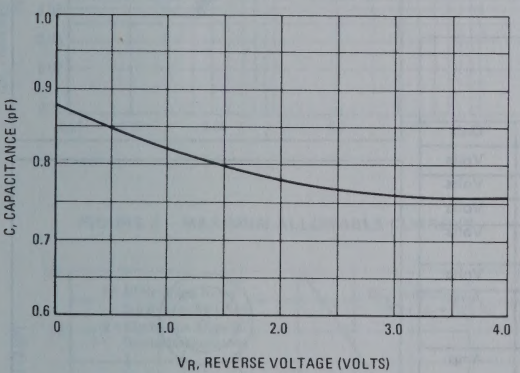


FIGURE 4 – NOISE FIGURE

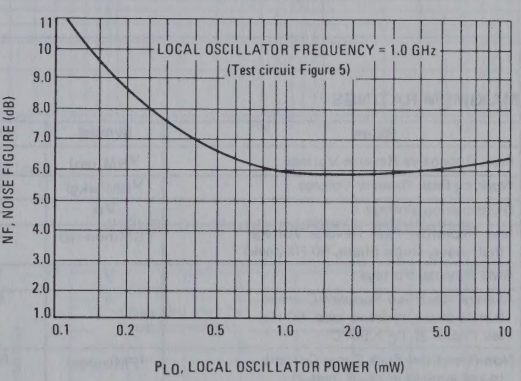
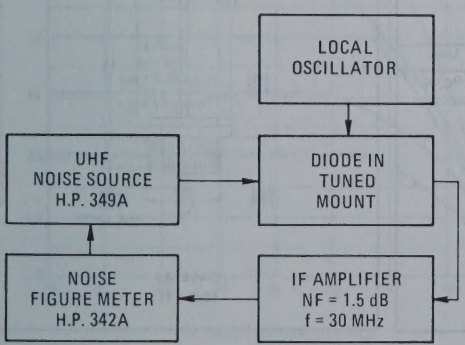


FIGURE 5 – NOISE FIGURE TEST CIRCUIT



NOTES ON TESTING AND SPECIFICATIONS

Note 1 – C_C and C_T are measured using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

Note 2 – Noise figure measured with diode under test in tuned diode mount using UHF noise source and local oscillator (LO) frequency of 1.0 GHz. The LO power is adjusted for 1.0 mW. IF amplifier NF = 1.5 dB, f = 30 MHz, see Figure 5.

Note 3 – L_S is measured on a package having a short instead of a die, using an impedance bridge (Boonton Radio Model 250A RX Meter).

MBD5500 (SILICON)

HOT CARRIER POWER RECTIFIER

. . . employing the Schottky Barrier principle in a large area metal-to-silicon power diode. State of the art geometry features epitaxial construction with oxide passivation and metal overlay contact.

- Extremely Low V_F
- Low Power Loss/High Efficiency
- Low Stored Charge, Majority Carrier Conduction
- High Surge Capacity
- Industry Standard Package

Designers Data for "Worst Case" Conditions

The Designers Data Sheets permit the design of most circuits entirely from the information presented. Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design.

HOT CARRIER POWER RECTIFIER

50 AMPERES
20 VOLTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Peak Repetitive Reverse Voltage	$V_{RM(rep)}$	20	Volts
Working Peak Reverse Voltage	$V_{RM(wkg)}$	20	Volts
DC Blocking Voltage	V_R	20	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 Hz peak)	$V_{RM(non-rep)}$	24	Volts
RMS Reverse Voltage	V_r	14	Volts
Average Rectified Forward Current (single phase, resistive load, 60 Hz, see Figure 2) $T_C = 50^oC$	I_O	50	Amp
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5)	$I_{FM(surge)}$	800	Amp
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.4	$^oC/W$

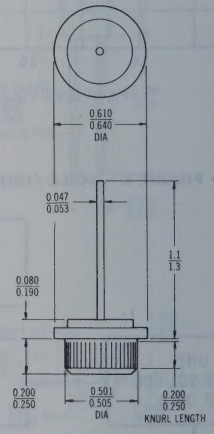
MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

FINISH: All external surfaces corrosion-resistant and the terminal lead is readily solderable.

POLARITY: Cathode to case.

MOUNTING POSITIONS: Any



CASE 43
(DO-21)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Instantaneous Forward Voltage Drop	V_F		Volts
(i_F = 100 Amps, T_C = 25°C)		0.65	
(i_F = 10 Amp, T_C = 25°C)		0.35	
Instantaneous Reverse Current	I_R		mA
(V_R = 20 V, T_C = 25°C)		200	
(V_R = 20 V, T_C = 100°C)		500	

FIGURE 1 – THERMAL RESPONSE

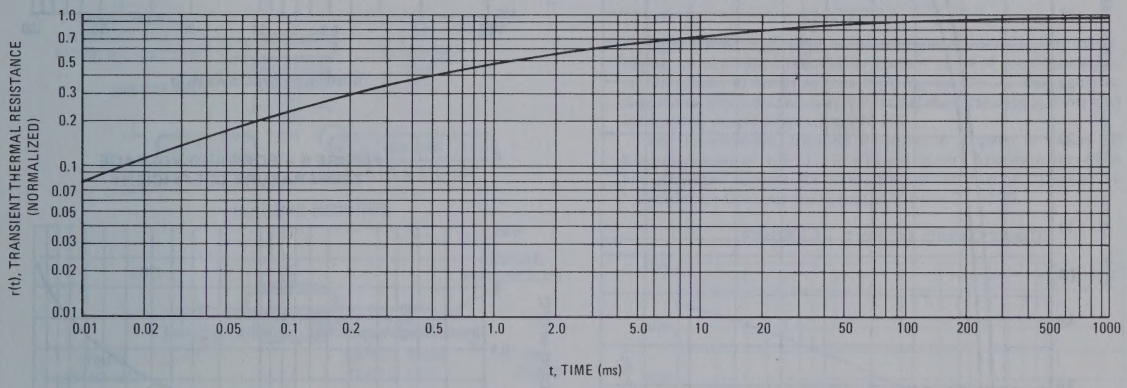


FIGURE 2 – MAXIMUM ALLOWABLE CURRENT

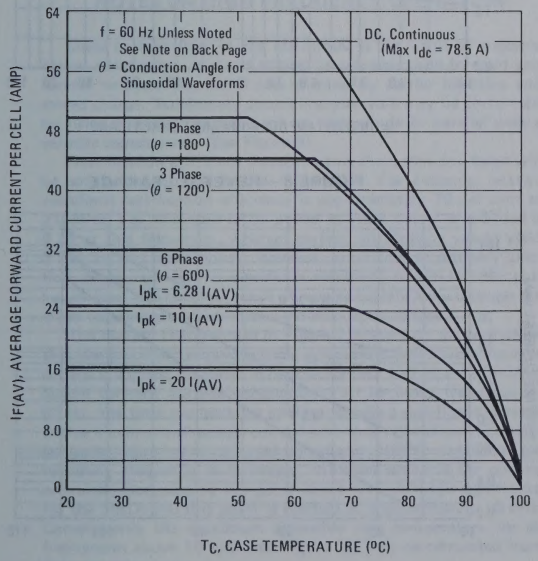


FIGURE 3 – MAXIMUM POWER DISSIPATION

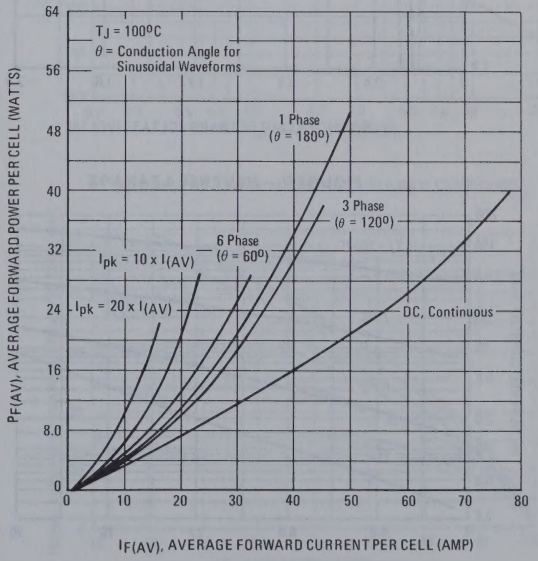


FIGURE 4 – FORWARD VOLTAGE

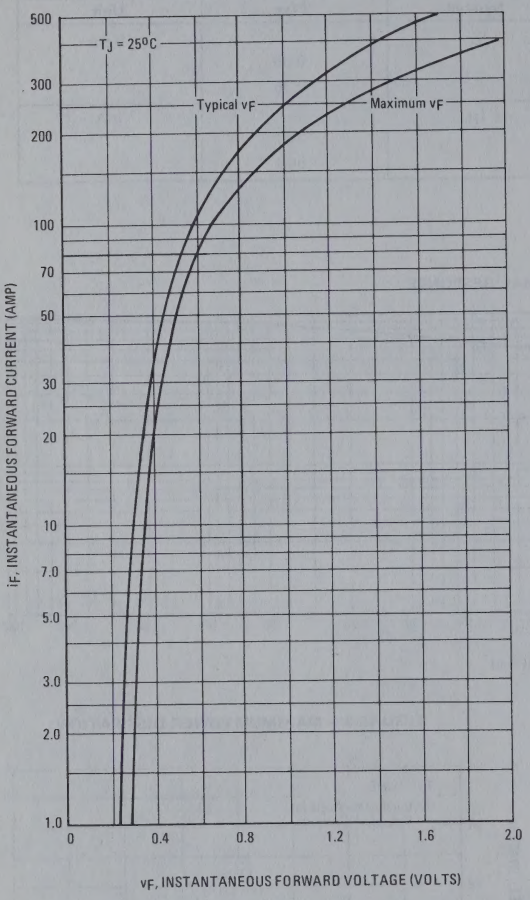


FIGURE 5 – MAXIMUM SURGE CAPABILITY

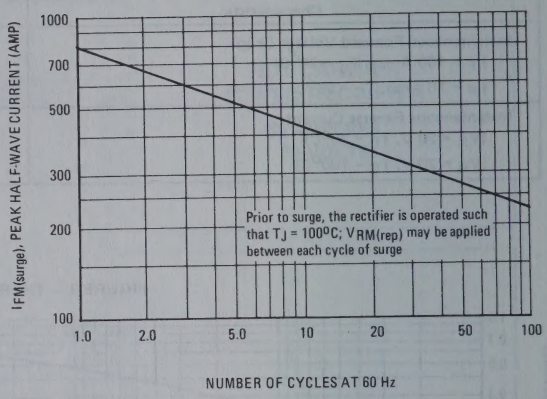


FIGURE 6 – FORWARD VOLTAGE TEMPERATURE COEFFICIENT

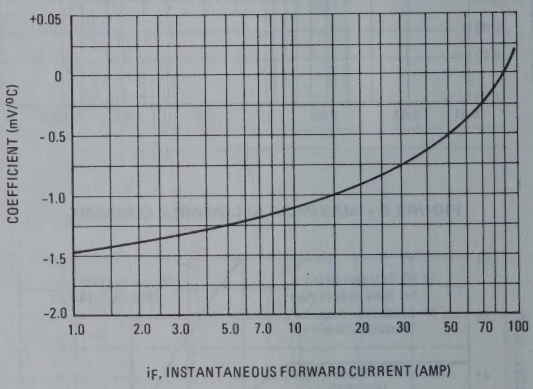


FIGURE 7 – REVERSE LEAKAGE

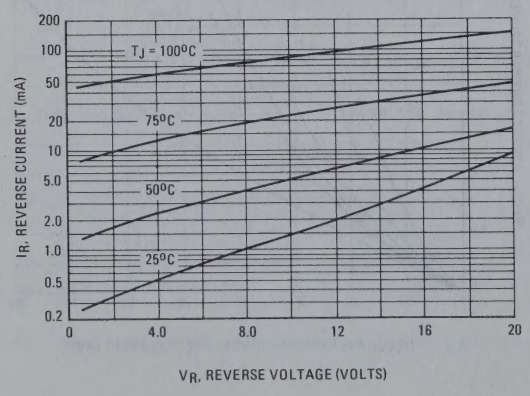
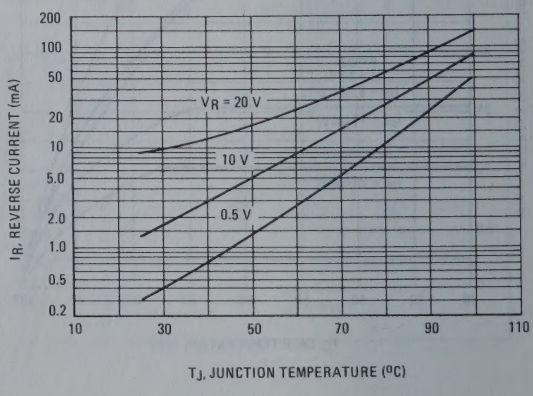


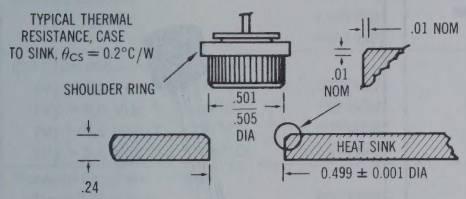
FIGURE 8 – REVERSE LEAKAGE



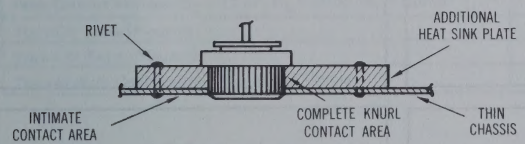
MOUNTING PROCEDURES

The Motorola MBD5500 rectifier is designed to be press-fitted in a heat sink to attain full device ratings. Recommended procedures for this type of mounting are as follows:

1. Drill a hole in the heat sink 0.499 ± 0.001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth and width of the break should be 0.010 inch maximum to retain maximum heat sink surface contact.
4. To prevent damage to the rectifier during press-in, the pressing force should be applied only on the shoulder ring of the rectifier case as shown.
5. The pressing force should be applied evenly about the shoulder ring to avoid tilting or canting of the rectifier case in the hole during the press-in operation. Also, the use of a light industrial lubricant will be of considerable aid.



HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

NOTES ON HIGH FREQUENCY OPERATION

Since current flow in the MBD5500 is the result of majority carrier conduction, it is not subject to normal diode forward and reverse recovery transients due to minority carrier injection and stored charge. Satisfactory circuit analysis work may be performed by using a model consisting of an ideal diode in parallel with a variable capacitance. (See Figure 9)

Rectification efficiency measurements show that operation will be satisfactory up to several megahertz. For example, relative waveform rectification efficiency is approximately 70 per cent at 2.0 MHz, e.g., the ratio of dc power to RMS power in the load is 0.28 at this frequency, whereas perfect rectification would yield 0.406 for sine wave inputs. However, in contrast to ordinary junction diodes, the loss in waveform efficiency is not indicative of power loss; it is simply a result of reverse current flow through the diode capacitance which lowers the dc output voltage.

The current rating shown in Figure 2 is based on the restriction that the junction temperature can not exceed 100°C when reverse voltage is applied; however, temperatures over 100°C are permitted during forward current conduction. At an input frequency of 60 Hz, the time available for cooling permits a significant increase in the maximum allowable current over that value if junction temperatures were never allowed to exceed 100°C. However, as operating frequency is increased, the time available for cooling eventually decreases to the point where it is no longer significant; for the MBD5500 this point is reached at approximately 10 kHz. Consequently the maximum allowable case temperature for all frequencies above 10 kHz (see Figure 10) may be calculated from the expression:

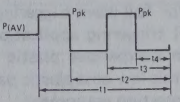
$$T_{C(Max)} = 100^{o}C - \theta_{JC} P_D$$

Values for P_D may be obtained from Figure 3 for sinusoidal waveforms.

At frequencies below 10 kHz, the following relationship is applicable:

$$T_{C(Max)} = 100^{o}C - \theta_{JC} [P_{(AV)} + (P_{pk} - P_{(AV)}) r(t_1) - P_{pk} r(t_2) + P_{pk} r(t_3) - P_{pk} r(t_4)]$$

The time reference is the time when reverse voltage is applied; $r(t_1)$, $r(t_2)$, etc., are taken from Figure 1 at times corresponding to t_1, t_2, etc.; the other factors are identified on the diagram below.



Peak power, P_{pk}, may be conservatively estimated by determining an equivalent rectangular current pulse of amplitude equal to the peak current, and multiplying by V_F at that current. Additional information on using thermal response data is contained in Motorola Application Note AN-292.

For convenience, derating information is given in Figure 10 for frequencies of 1.0 KC, 10 KC and above. Approximate values for allowable current for other frequencies can be obtained by interpolation between the curves of Figures 2 and 10.

FIGURE 9 – TYPICAL CAPACITANCE

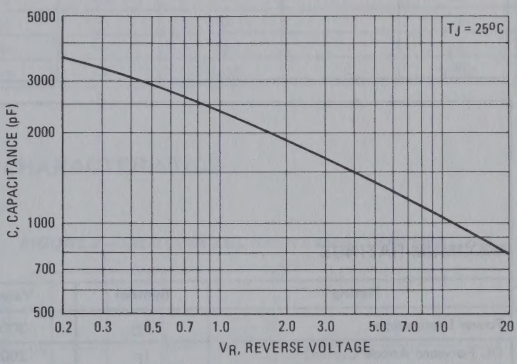
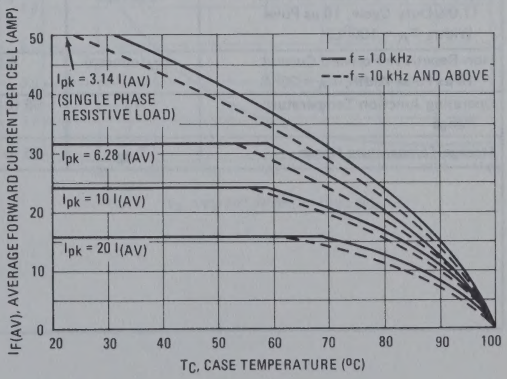
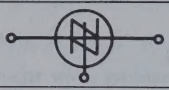


FIGURE 10 – MAXIMUM ALLOWABLE CURRENT



MBS4991 (SILICON)
MBS4992



SILICON BIDIRECTIONAL SWITCH (PLASTIC)

6.0–10 VOLTS
300 mW

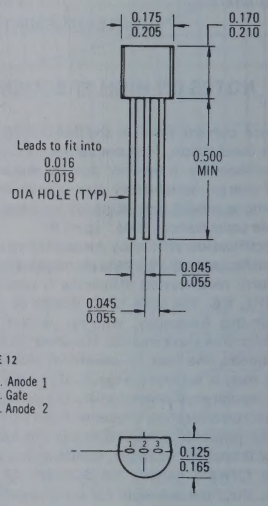
SILICON BIDIRECTIONAL SWITCH

. . . designed for full-wave triggering in Triac phase control circuits, half-wave SCR triggering application and as voltage level detectors. Supplied in an inexpensive plastic TO-92 package for high-volume requirements, this low-cost plastic package is readily adaptable for use in automatic insertion equipment.

- Low Switching Voltage – 8.0 Volts Typical
- Uniform Characteristics in Each Direction
- Low On-State Voltage – 1.7 Volts Maximum
- Low Off-State Current – 0.1 μA Maximum
- Low Temperature Coefficient – 0.02 %/°C Typical

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Dissipation	P_D	300	mW
DC Forward Anode Current	I_F	200	mA
DC Gate Current (off-state only)	$I_{G(off)}$	5.0	mA
Repetitive Peak Forward Current (1.0% Duty Cycle, 10 μs Pulse Width, T_A = 100°C)	$I_{FM(rep)}$	2.0	Amp
Non-Repetitive Forward Current 10 μs Pulse Width, T_A = 25°C	$I_{FM(nonrep)}$	6.0	Amp
Operating Junction Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



CASE 29–02

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Switching Voltage		V_S				Vdc
	MBS4991		6.0	8.0	10	
	MBS4992		7.5	8.0	9.0	
Switching Current		I_S				μAdc
	MBS4991		–	175	350	
	MBS4992		–	90	120	
Switching Voltage Differential		$\lvert V_{S1}-V_{S2}\rvert$				Vdc
	MBS4991		–	0.3	0.5	
	MBS4992		–	0.1	0.2	
Gate Trigger Current		I_{GF}				μAdc
(V_F = 5.0 Vdc R_L = 1.0 K ohm)	MBS4992		–	–	100	
Holding Current		I_H				mAdc
	MBS4991		–	0.7	1.5	
	MBS4992		–	0.2	0.5	
Off-State Blocking Current		I_B				μAdc
(V_F = 5.0 Vdc, T_A = 25°C)	MBS4991		–	0.08	1.0	
(V_F = 5.0 Vdc, T_A = 85°C)	MBS4991		–	6.0	10	
(V_F = 5.0 Vdc, T_A = 25°C)	MBS4992		–	0.08	0.1	
(V_F = 5.0 Vdc, T_A = 100°C)	MBS4992		–	6.0	10	
Forward On-State Voltage		V_F				Vdc
(I_F = 175 mAdc)	MBS4991		–	1.4	1.7	
(I_F = 200 mAdc)	MBS4992		–	1.5	1.7	
Peak Output Voltage (C_c = 0.1 μF, R_L = 20 ohms, Figure 7)		V_o	3.5	4.8	–	Vdc
Turn-On Time (Figure 8)		t_{on}	–	1.0	–	μs
Turn-Off Time (Figure 9)		t_{off}	–	30	–	μs
Temperature Coefficient of Switching Voltage		T_C	–	+0.02	–	%/°C

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 1 – SWITCHING VOLTAGE

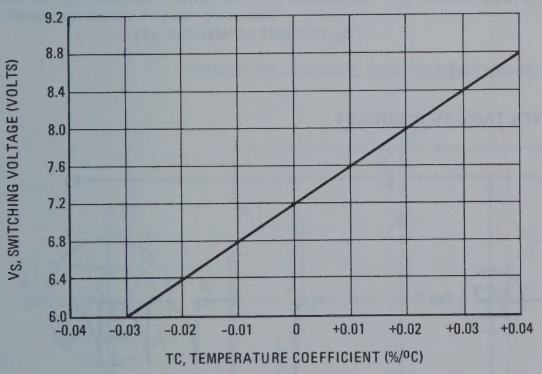


FIGURE 2 – SWITCHING CURRENT versus TEMPERATURE

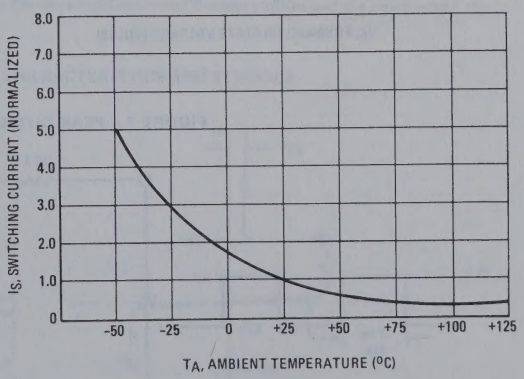


FIGURE 3 – HOLDING CURRENT versus TEMPERATURE

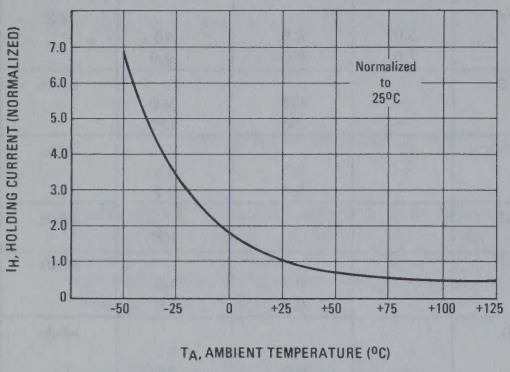


FIGURE 4 – OFF-STATE BLOCKING CURRENT versus TEMPERATURE

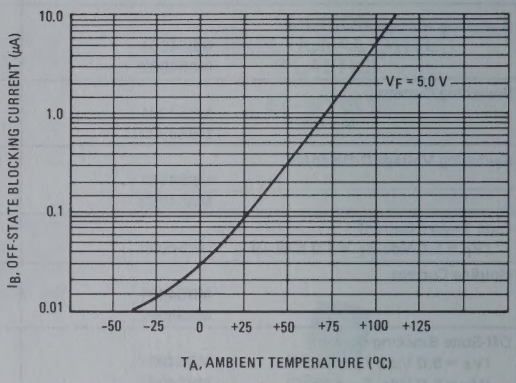


FIGURE 5 – ON-STATE VOLTAGE versus FORWARD CURRENT

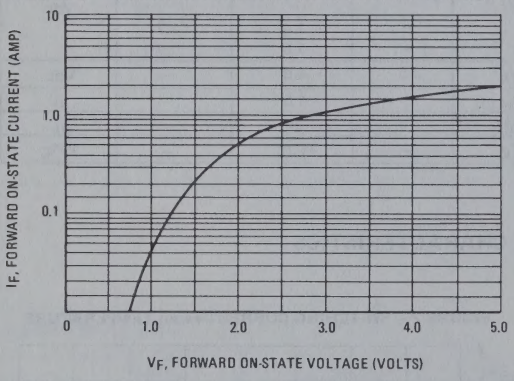


FIGURE 6 – OUTPUT VOLTAGE (FUNCTION OF R_L AND C_c)

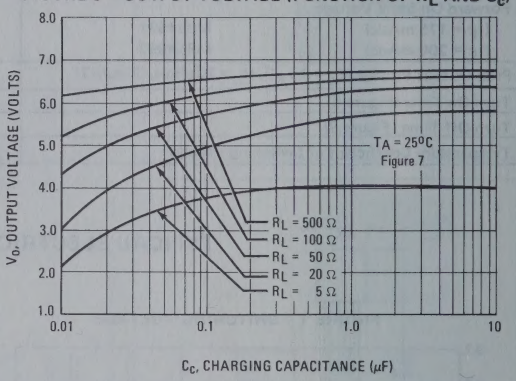


FIGURE 7 – PEAK OUTPUT VOLTAGE TEST CIRCUIT

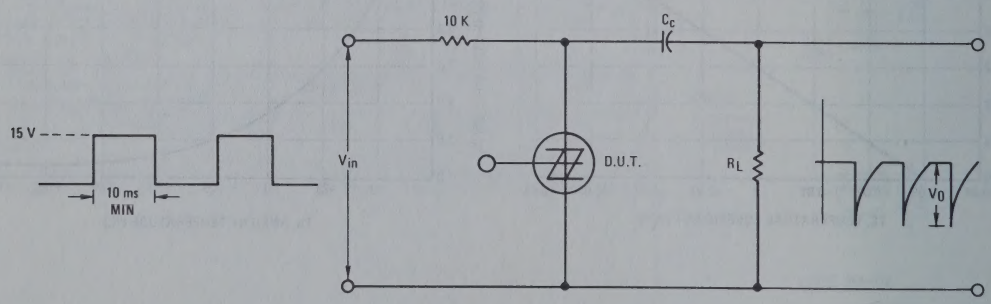
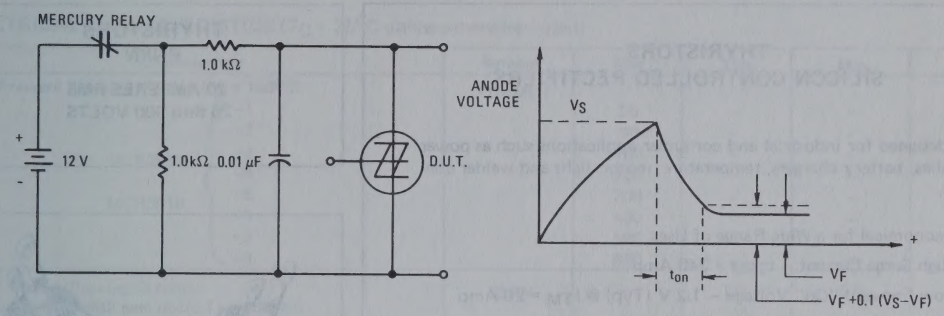
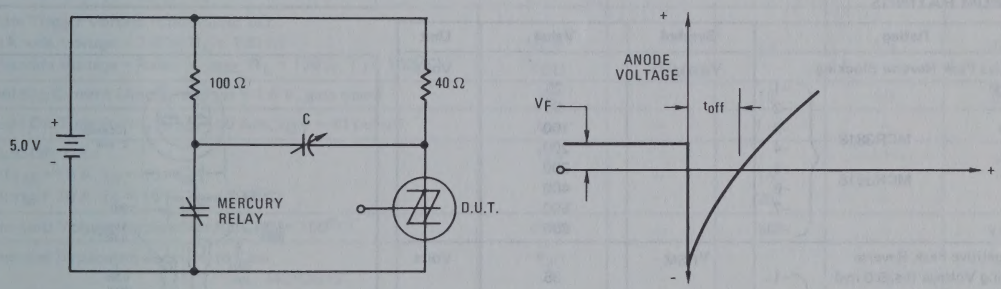


FIGURE 8 – TURN-ON TIME TEST CIRCUIT



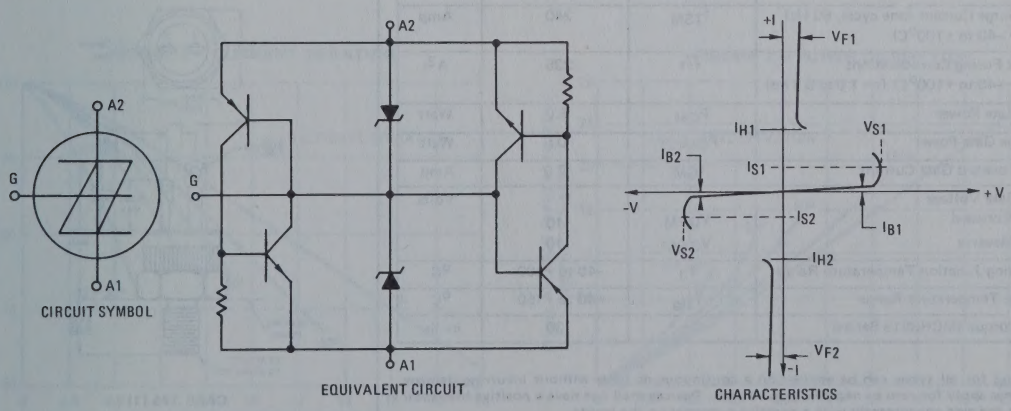
Turn-on time is measured from the time V_S is achieved to the time when the anode voltage drops to within 90% of the difference between V_S and V_F.

FIGURE 9 – TURN-OFF TIME TEST CIRCUIT



With the SBS in conduction and the relay contacts open, the contacts are closed and the anode is driven negative. C is decreased, and when the anode voltage becomes positive, the SBS remains off. The turn-off time, t_{off}, is the time between initial contact closure and the point where the anode voltage passes through zero volts.

FIGURE 10 – DEVICE EQUIVALENT CIRCUIT, CHARACTERISTICS AND SYMBOLS



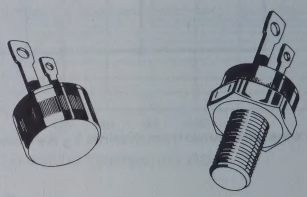
MCR3818-1 thru MCR3818-8 (SILICON)
MCR3918-1 thru MCR3918-8

THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 240 Amp
- Low Forward "On" Voltage — 1.2 V (Typ) @ I_{TM} = 20 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ $T_C = 25^oC$
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN
20 AMPERES RMS
25 thru 600 VOLTS

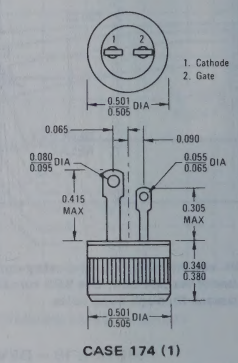


MCR3818 Series MCR3918 Series

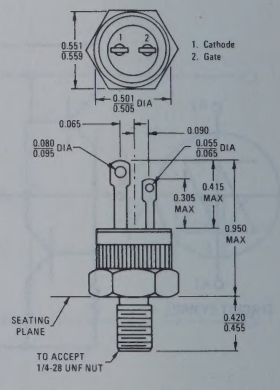
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage		V_{RRM}(1)		Volts
	-1		25	
	-2		50	
MCR3818	-3		100	
	-4		200	
MCR3918	-5		300	
	-6		400	
	-7		500	
	-8		600	
Non-repetitive Peak Reverse Blocking Voltage ($t \leq 5.0$ ms)		V_{RSM}		Volts
	-1		35	
	-2		75	
MCR3818	-3		150	
	-4		300	
MCR3918	-5		400	
	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	20	Amp
Peak Surge Current (one cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	240	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	235	A^2s
Peak Gate Power		P_{GM}	5.0	Watt
Average Gate Power		$P_{G(AV)}$	0.5	Watt
Peak Forward Gate Current		I_{GM}	2.0	Amp
Peak Gate Voltage				Volts
Forward		V_{GFM}	10	
Reverse		V_{GRM}	10	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3918 Series)		—	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.



CASE 174 (1)



CASE 175 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)	V_{DRM}(1)				Volts
MCR3818 -1		25	–	–	
MCR3818 -2		50	–	–	
MCR3818 -3		100	–	–	
MCR3818 -4		200	–	–	
MCR3918 -5		300	–	–	
MCR3918 -6		400	–	–	
MCR3918 -7		500	–	–	
MCR3918 -8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)	I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)	I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 20 A Peak)	V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)	V_{GT}	–	0.7	1.5	Volts
(Anode Voltage = Rated V_{DRM}, R_L = 100 Ω, T_J = 100°C)	V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 V, gate open)	I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 20 Adc, I_{GT} = 40 mAdc)	t_{on}	–	1.0	–	μs
Turn-Off Time	t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)		–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)		–	25	–	
Forward Voltage Application Rate (T_J = 100°C)	dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case	θ_{JC}	–			°C/W
MCR3818		–	–	1.5	
MCR3918		–	–	1.6	

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING

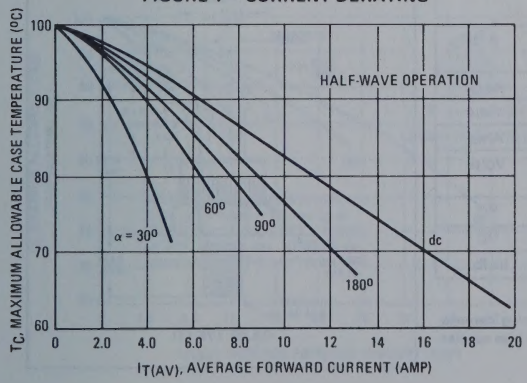
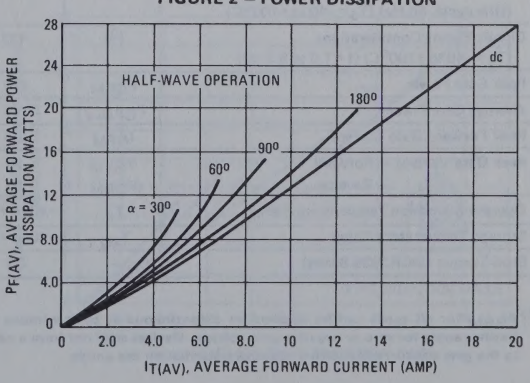


FIGURE 2 – POWER DISSIPATION



MCR3835-1 thru MCR3835-8 (SILICON)
MCR3935-1 thru MCR3935-8

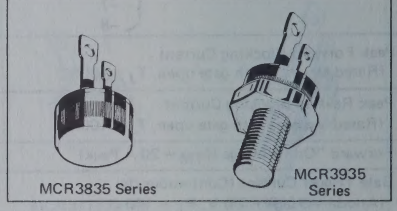
THYRISTORS
SILICON CONTROLLED RECTIFIERS

. . . designed for industrial and consumer applications such as power supplies, battery chargers, temperature, motor, light and welder controls.

- Economical for a Wide Range of Uses
- High Surge Current — I_{TSM} = 325 Amp
- Low Forward "On" Voltage — 1.2 V (Typ) @ I_{TM} = 35 Amp
- Practical Level Triggering and Holding Characteristics — 10 mA (Typ) @ T_C = 25°C
- Rugged Construction in Either Pressfit or Stud Package

THYRISTORS
PNPN

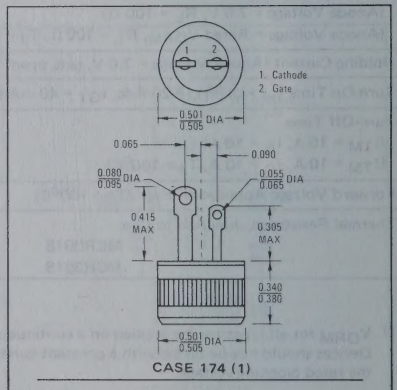
35 AMPERES RMS
25 thru 600 VOLTS



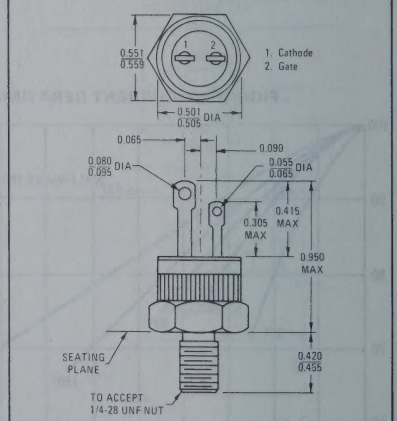
MAXIMUM RATINGS

Rating		Symbol	Value	Unit
Repetitive Peak Reverse Blocking Voltage		V_{RRM}(1)		Volts
	-1		25	
	-2		50	
MCR3835	-3		100	
	-4		200	
	-5		300	
MCR3935	-6		400	
	-7		500	
	-8		600	
Non-Repetitive Peak Reverse Blocking Voltage ($t \leq 5.0$ ms)		V_{RSM}		Volts
	-1		35	
	-2		75	
MCR3835	-3		150	
	-4		300	
	-5		400	
MCR3935	-6		500	
	-7		600	
	-8		700	
Forward Current RMS		$I_{T(RMS)}$	35	Amp
Peak Surge Current (One cycle, 60 Hz) (T_J = -40 to +100°C)		I_{TSM}	325	Amp
Circuit Fusing Considerations (T_J = -40 to +100°C) (t = 1.0 to 8.3 ms)		I^2t	435	A^2s
Peak Gate Power		P_{GFM}	5.0	Watts
Average Gate Power		$P_{GF(AV)}$	0.5	Watt
Peak Forward-Gate Current		I_{GFM}	2.0	Amp
Peak Gate Voltage — Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	10	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +150	°C
Stud Torque (MCR3935 Series)		—	30	in. lb.

(1) V_{RRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices shall not have a positive bias applied to the gate concurrently with a negative potential on the anode.



CASE 174 (1)



CASE 175 (1)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Peak Forward Blocking Voltage (T_J = 100°C)		V_{DRM}(1)				Volts
	-1		25	–	–	
	-2		50	–	–	
	-3		100	–	–	
MCR3835	-4		200	–	–	
	-5		300	–	–	
MCR3935	-6		400	–	–	
	-7		500	–	–	
	-8		600	–	–	
Peak Forward Blocking Current (Rated V_{DRM}, with gate open, T_J = 100°C)		I_{DRM}	–	1.0	5.0	mA
Peak Reverse Blocking Current (Rated V_{RRM}, with gate open, T_J = 100°C)		I_{RRM}	–	1.0	5.0	mA
Forward "On" Voltage (I_{TM} = 35 A Peak)		V_{TM}	–	1.2	1.5	Volts
Gate Trigger Current (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)		I_{GT}	–	10	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7.0 V, R_L = 100 Ω)		V_{GT}	–	0.7	1.5	Volts
(Anode Voltage = Rated V_{DM}, R_L = 100 Ω, T_J = 100°C)		V_{GD}	0.2	–	–	
Holding Current (Anode Voltage = 7.0 V, gate open)		I_H	–	10	50	mA
Turn-On Time ($t_d + t_r$) (I_{TM} = 35 Adc, I_{GT} = 40 mAdc)		t_{on}	–	1.0	–	μs
Turn-Off Time		t_{off}				μs
(I_{TM} = 10 A, I_R = 10 A)			–	15	–	
(I_{TM} = 10 A, I_R = 10 A, T_J = 100°C)			–	25	–	
Forward Voltage Application Rate (T_J = 100°C)		dv/dt	–	50	–	V/μs
Thermal Resistance, Junction to Case	MCR3835	θ_{JC}	–	–	1.2	°C/W
	MCR3935		–	–	1.3	

(1) V_{DRM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. Devices should not be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

FIGURE 1 – CURRENT DERATING

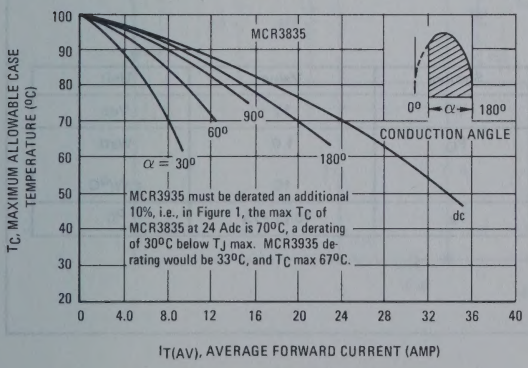
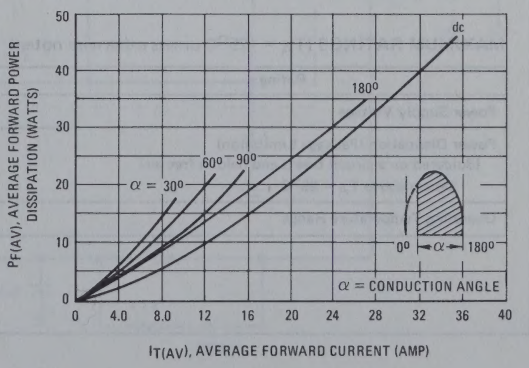


FIGURE 2 – TYPICAL POWER DISSIPATION



MFC6000P

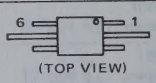
Advance Information

1/4-WATT AUDIO AMPLIFIER

. . . designed for the output stage of battery-powered portable radios.

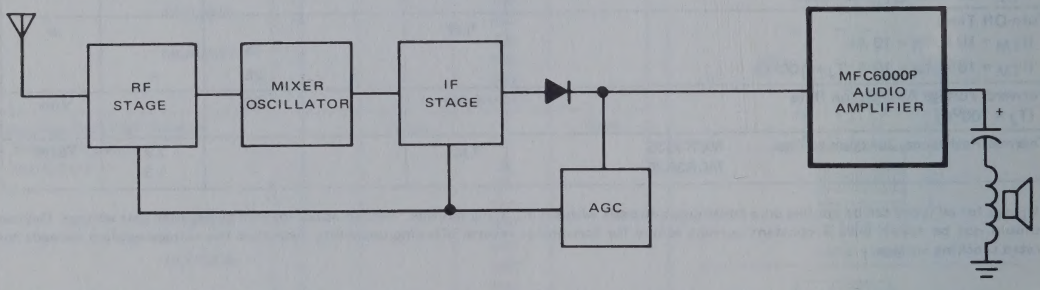
- 250 mW of Audio Output Power
- Low Standby Current – 5.0 mA typical
- Low Harmonic Distortion
- High Sensitivity – 5.0 mV Input for 50 mW Output

1/4-WATT AUDIO AMPLIFIER
SILICON MONOLITHIC
CONSUMER CIRCUIT



CASE 643
PLASTIC PACKAGE

TYPICAL APPLICATION



MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

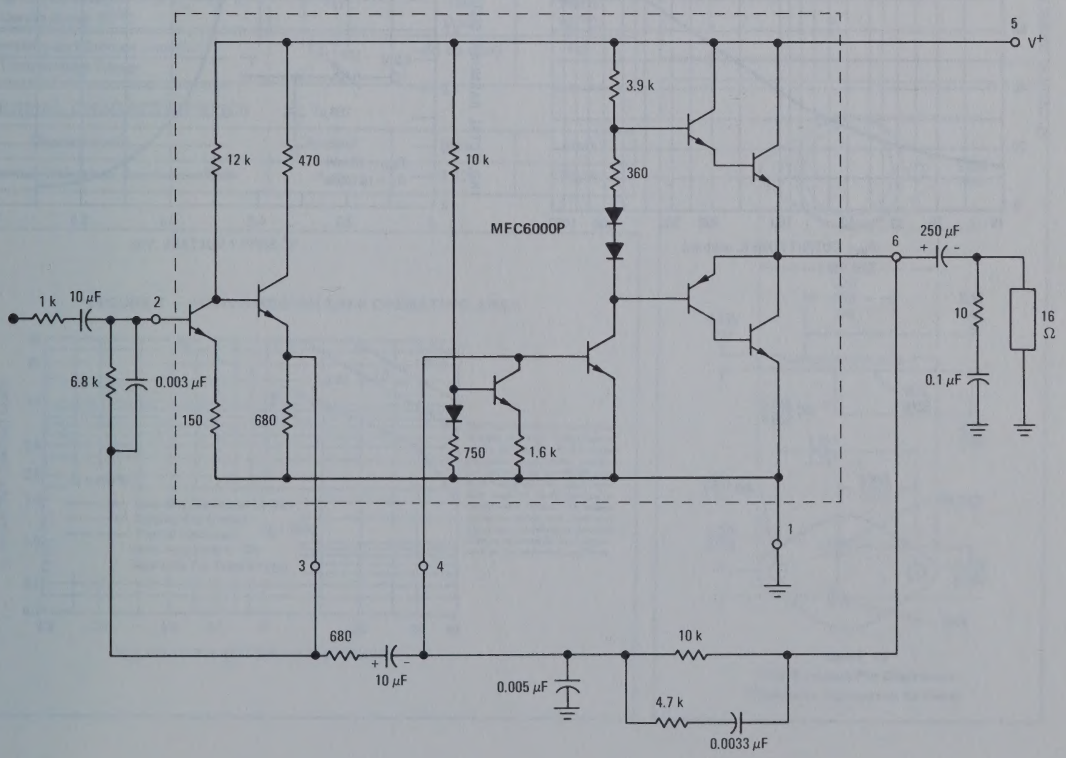
Rating	Symbol	Value	Unit
Power Supply Voltage	V^+	12	Vdc
Power Dissipation (Package Limitation) (Soldered on a circuit board and held in free air) Derate above T_A = 25°C	P_D	1.0 10	Watt mW/°C
Operating Temperature Range	T_A	-10 to +75	°C

ELECTRICAL CHARACTERISTICS* (V^+ = 9.0 Vdc, R_L = 16 Ohms, T_A = +25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Zero Signal Current Drain	I_D	–	5.0	8.0	mAdc
Sensitivity P_{out} = 50 mW(rms)	e_{in}	–	5.0	8.0	mV(rms)
Output Power Total Harmonic Distortion ≤ 10%	P_{out}	250	350	–	mW(rms)
Total Harmonic Distortion	THD				%
P_{out} = 50 mW(rms)		–	0.8	–	
P_{out} = 50 mW(rms), V^+ = 6.0 Vdc		–	4.2	–	

*As measured in test circuit shown in Figure 1.

FIGURE 1 – TEST CIRCUIT



TYPICAL CHARACTERISTICS
(R_L = 16 Ohms, T_A = 25°C)

FIGURE 2 – TOTAL HARMONIC DISTORTION versus OUTPUT POWER
(V^+ = 9.0 Vdc)

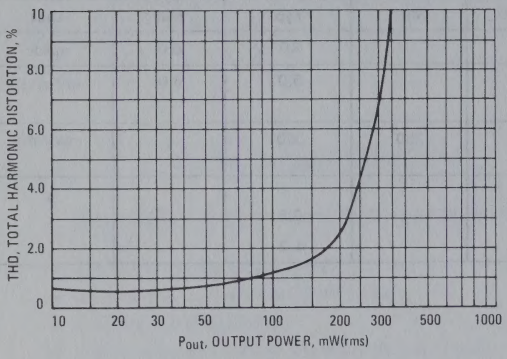


FIGURE 3 – TOTAL HARMONIC DISTORTION versus OUTPUT POWER
(V^+ = 6.0 Vdc)

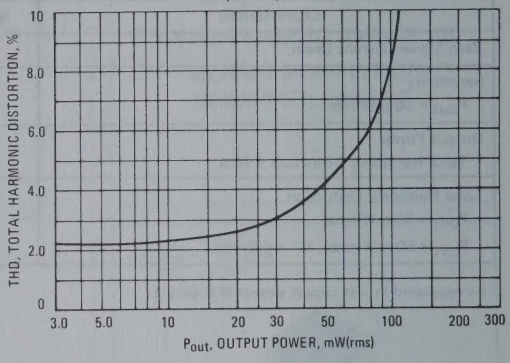


FIGURE 4 – CURRENT DRAIN versus OUTPUT POWER

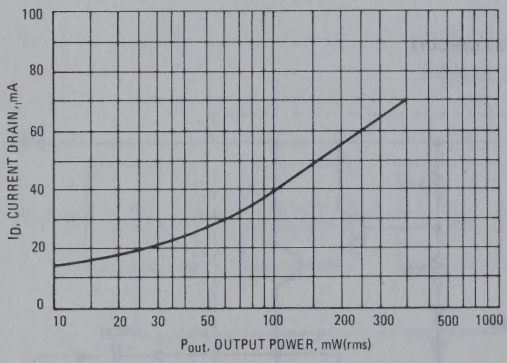
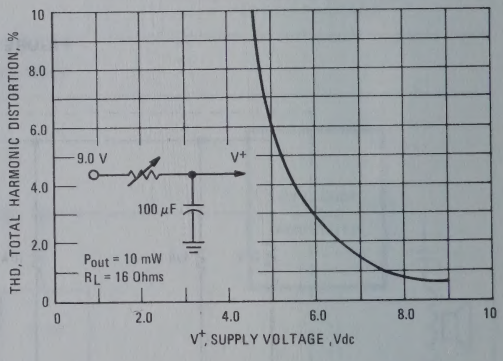


FIGURE 5 – TOTAL HARMONIC DISTORTION versus SUPPLY VOLTAGE



MJ450 (SILICON)

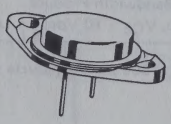
HIGH-POWER PNP SILICON TRANSISTOR

. . . designed for high-current switching and general purpose amplifier applications.

- Low Saturation Voltage – $V_{CE(sat)}$ = 1.0 Vdc @ I_C = 10 Adc
- DC Current Gain – h_{FE} = 20 (Min) @ I_C = 10 Adc
- Excellent Safe Area Characteristics

30 AMPERE
POWER TRANSISTOR
PNP SILICON

40 VOLTS
150 WATTS



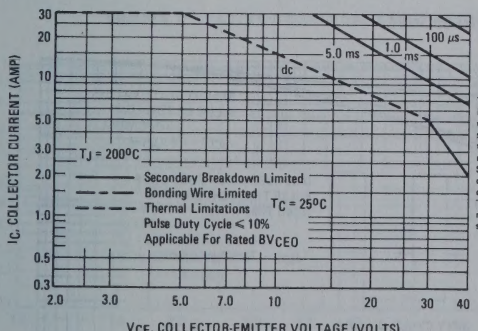
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Collector Current – Continuous	I_C	30	Adc
Base Current	I_B	5.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.86	Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–65 to +200	°C

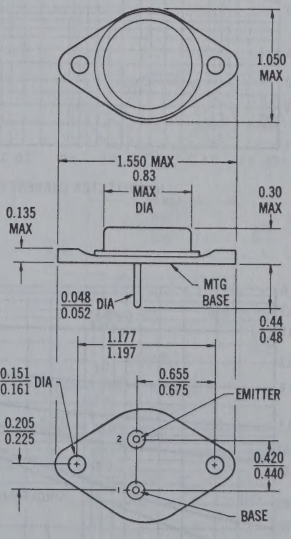
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 12
(TO-3 except Pin Diameter)
(Collector Connected to Case)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage(1) (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	40	–	Vdc
Collector-Base Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	1.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)	I_{EBO}	–	10	mAdc
ON CHARACTERISTICS				
DC Current Gain(1) (I_C = 10 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	20	–	–
Collector-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	–	1.0	Vdc
Base-Emitter Saturation Voltage(1) (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	–	1.5	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)	f_T	2.0	–	MHz

(1) Pulse Test: PW ≤ 300 μs, Duty Cycle ≤ 2.0%.

FIGURE 2 – NORMALIZED DC CURRENT GAIN

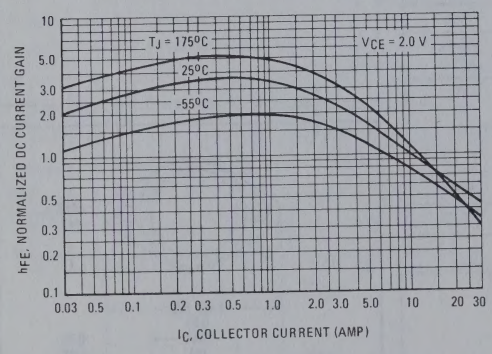


FIGURE 3 – "ON" VOLTAGES

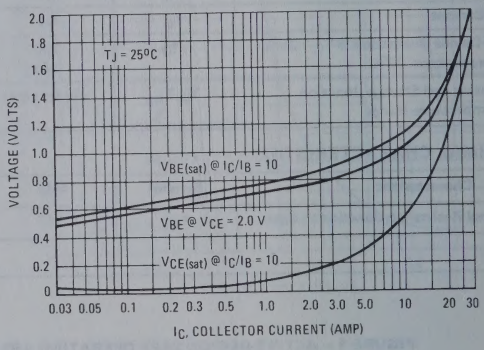
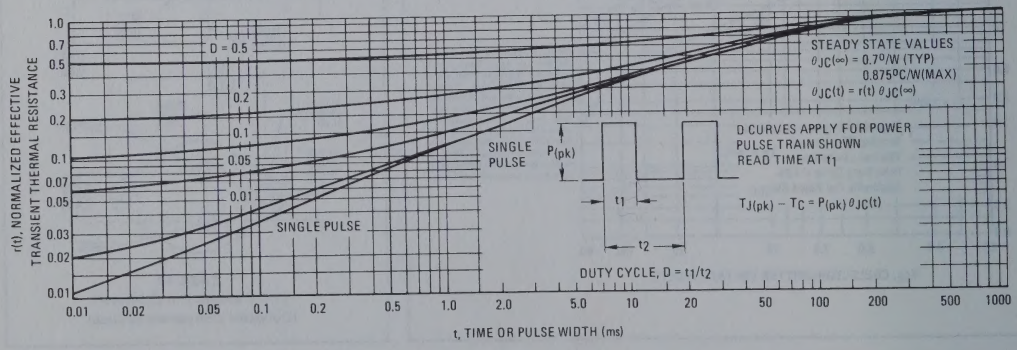


FIGURE 4 – THERMAL RESPONSE



MJ480 (SILICON)
MJ481

NPN SILICON POWER TRANSISTORS

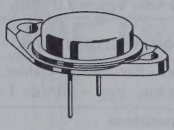
. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain—Bandwidth Product — f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain — h_{FE} = 30–200 @ I_C = 1.0 Adc
- Complements to PNP MJ490 and MJ491

4 AMPERE POWER TRANSISTORS

NPN SILICON

40–60 VOLTS
87.5 WATTS



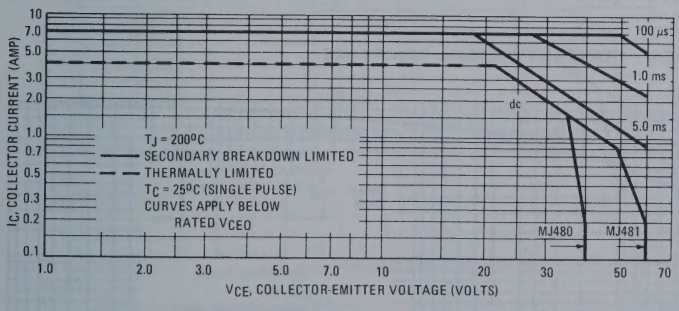
MAXIMUM RATINGS

Rating	Symbol	MJ480	MJ481	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

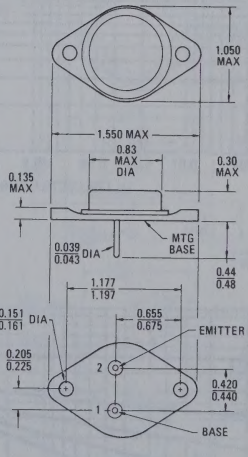
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 11
TO-3
Collector Connected to Case

MJ480, MJ481 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	MJ480 MJ481	BV_{CEO}	 40 60	 – –	Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		I_{CBO}	– –	1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	 50 30 10	 – 200 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	– –	0.4 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	– –	1.0 1.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	– –	1.2 1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

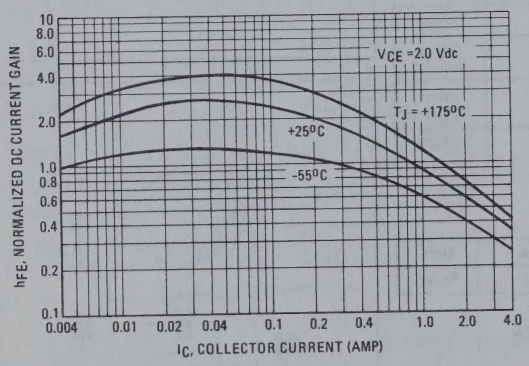


FIGURE 3 – "ON" VOLTAGES

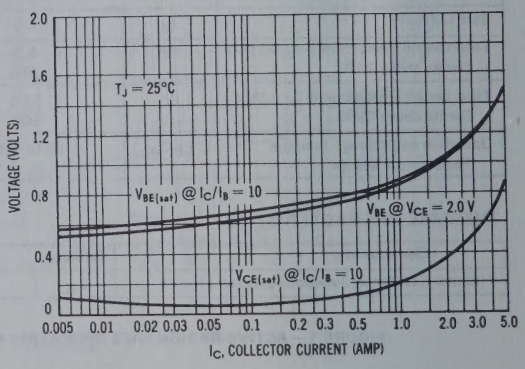
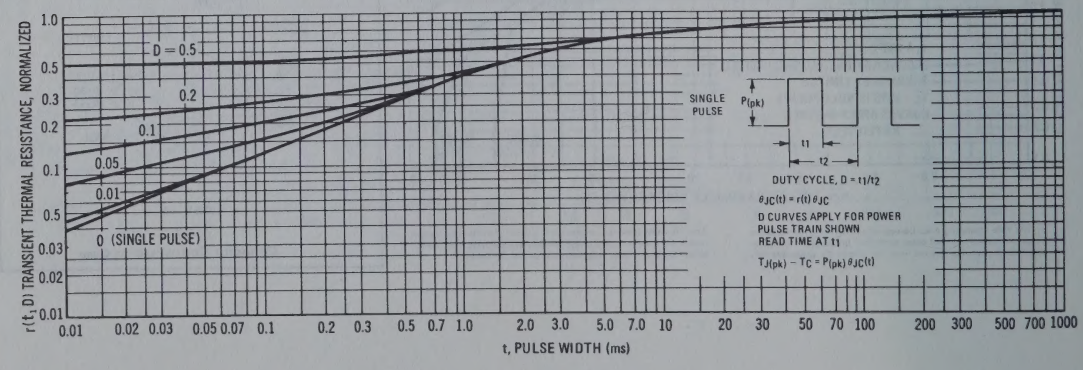


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



MJ490 (SILICON)
MJ491

PNP SILICON POWER TRANSISTORS

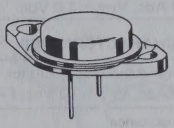
. . . designed for general-purpose and 5 to 20 Watt audio amplifier applications.

- Current-Gain—Bandwidth Product — f_T = 4.0 MHz (Min) @ I_C = 1.0 Adc
- DC Current Gain — h_{FE} = 30-200 @ I_C = 1.0 Adc
- Complements to NPN MJ480 and MJ481

4 AMPERE POWER TRANSISTORS

PNP SILICON

40-60 VOLTS
87.5 WATTS



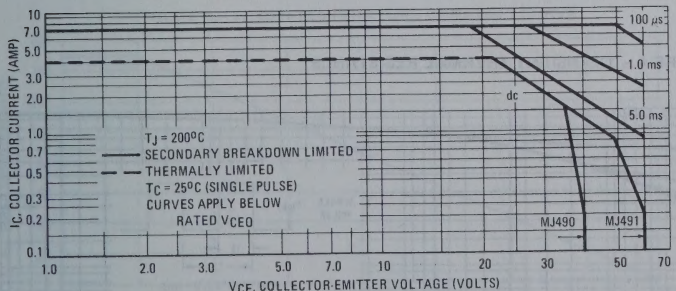
MAXIMUM RATINGS

Rating	Symbol	MJ490	MJ491	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Collector-Base Voltage	V_{CB}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0		Vdc
Collector Current — Continuous Peak	I_C	4.0 7.0		Adc
Base Current	I_B	1.0		Adc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	5.0 28.6		Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	87.5 500		Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

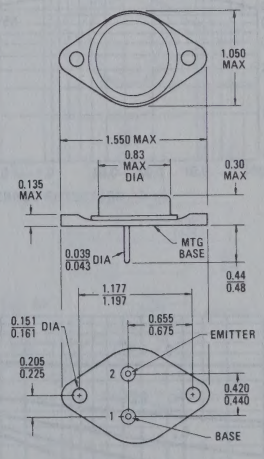
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	2.0	°C/W

FIGURE 1 — ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



CASE 11
TO-3
Collector Connected to Case

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 0.2 Adc, I_B = 0)	MJ490 MJ491	BV_{CEO}	 40 60	 – –	Vdc
Collector Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		I_{CBO}	 – –	 1.0 5.0	mAdc
Emitter Cutoff Current (V_{BE} = 5.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2.0 Vdc) (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		h_{FE}	 50 30 10	 – 200 –	–
Collector-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{CE(sat)}$	 – –	 0.4 1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 1.0 Adc, I_B = 0.1 Adc) (I_C = 3.0 Adc, I_B = 0.3 Adc)		$V_{BE(sat)}$	 – –	 1.0 1.5	Vdc
Base-Emitter "On" Voltage (I_C = 1.0 Adc, V_{CE} = 2.0 Vdc) (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)		$V_{BE(on)}$	 – –	 1.2 1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	4.0	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 0.1 MHz)		C_{ob}	–	200	pF

FIGURE 2 – NORMALIZED DC CURRENT GAIN

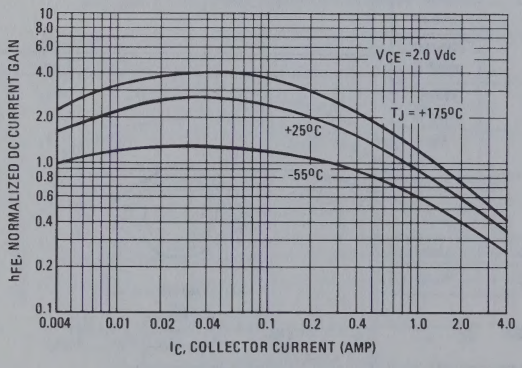


FIGURE 3 – "ON" VOLTAGE

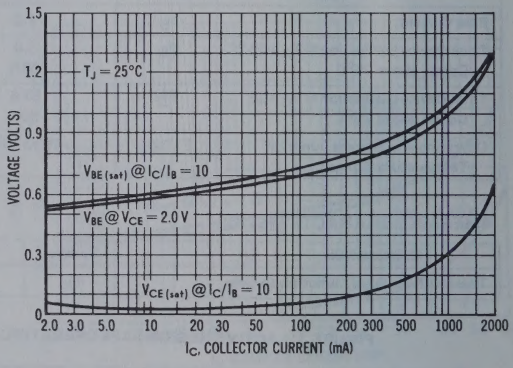
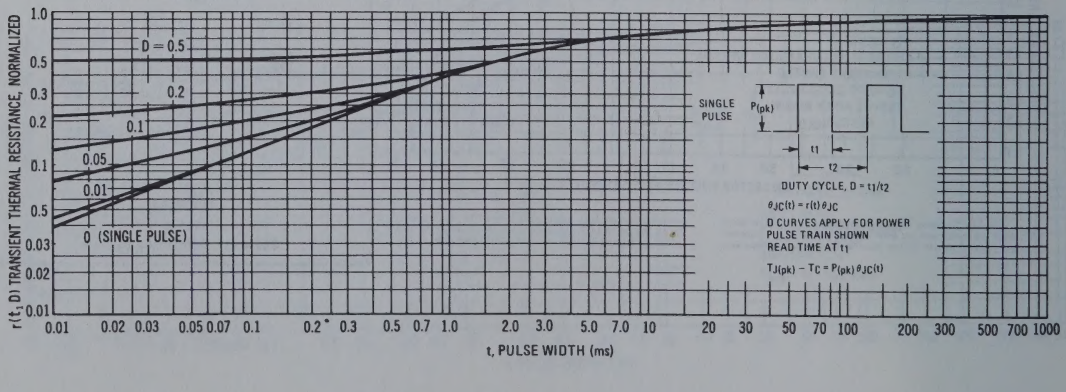


FIGURE 4 – TRANSIENT THERMAL RESISTANCE



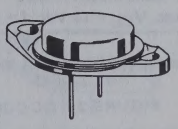
MJ2840 (SILICON)
MJ2841

HIGH-POWER NPN SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain –
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2840)
  = 4.0 Adc (MJ2841)
- Complement to PNP MJ2940 and MJ2941

10 AMPERE
POWER TRANSISTORS
NPN SILICON
60–80 VOLTS
150 WATTS



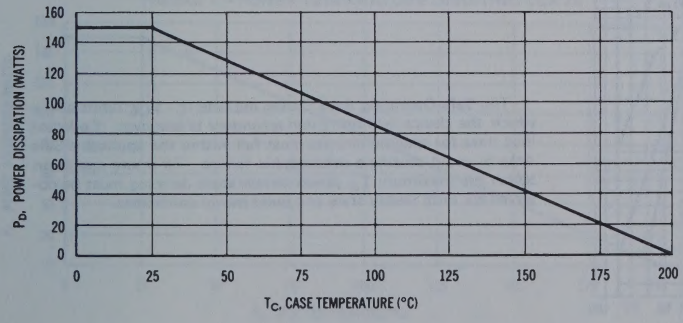
MAXIMUM RATINGS

Rating	Symbol	MJ2840	MJ2841	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

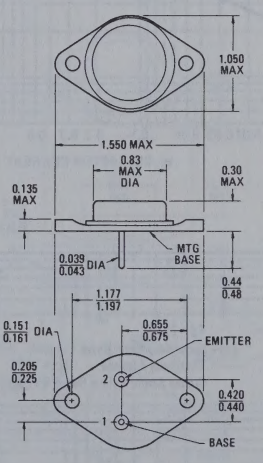
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



CASE 11
(TO-3)
Collector Connected to Case

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	MJ2840 MJ2841	$BV_{CEO(sus)}$	60 80	– –	Vdc
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0)	Both Types	I_{CBO}	0.1	–	mAdc
(V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)	Both Types		2.0	–	
Base-Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	Both Types	I_{EBO}	1.0	–	mAdc
ON CHARACTERISTICS					
DC Current Gain[1] (I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types	h_{FE}	40	–	–
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840		20	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2841		20	100	
Base-Emitter On Voltage[1] (I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2840	$V_{BE(on)}$	–	1.3	Vdc
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2841		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 MHz)		f_T	2.0	20	MHz

[1] Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

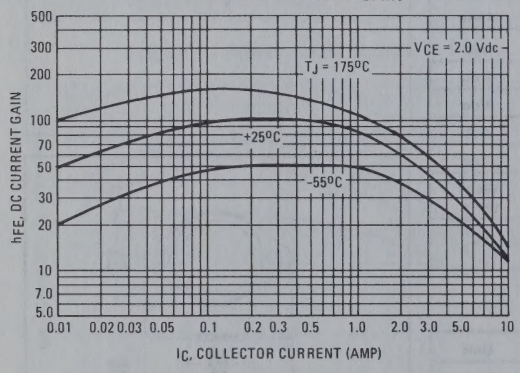


FIGURE 3 – "ON" VOLTAGES

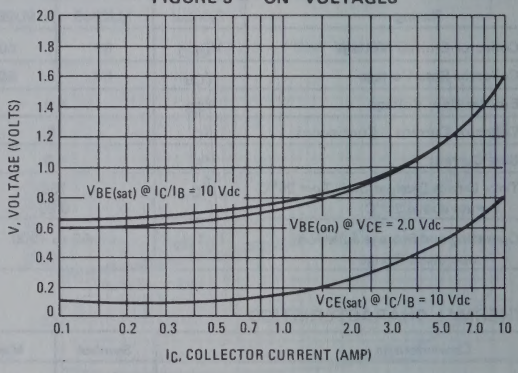
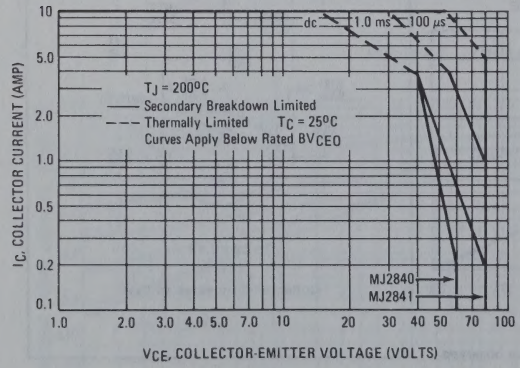


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

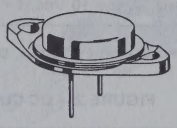
MJ2940 (SILICON)
MJ2941

HIGH-POWER PNP SILICON TRANSISTORS

. . . designed for use in audio amplifier circuits utilizing complementary symmetry.

- Excellent Safe Operating Area
- DC Current Gain –
  h_{FE} = 20 - 100 @ I_C = 3.0 Adc (MJ2940)
  = 4.0 Adc (MJ2941)
- Complement to NPN MJ2840 and MJ2841

10 AMPERE
POWER TRANSISTORS
PNP SILICON
60–80 VOLTS
150 WATTS



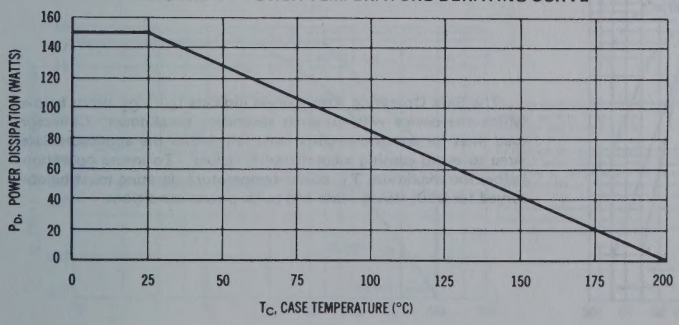
MAXIMUM RATINGS

Rating	Symbol	MJ2940	MJ2941	Unit
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current – Continuous	I_C	10		Adc
Base Current	I_B	4.0		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	150 0.85		Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200		°C

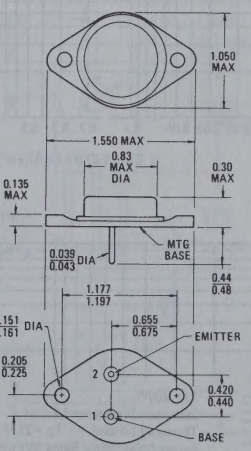
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	1.17	°C/W

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figure 4. Both limits are applicable and must be observed.



CASE 11
(TO-3)
Collector Connected to Case

ELECTRICAL CHARACTERISTIC (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage[1] (I_C = 200 mAdc, I_B = 0)	MJ2940 MJ2941	$V_{CEO(sus)}$	60 80	– –	Vdc
Collector-Base Cutoff Current (V_{CB} = Rated V_{CB}, I_E = 0) (V_{CB} = Rated V_{CB}, I_E = 0, T_C = 150°C)		I_{CBO}	– –	0.1 3.0	mAdc
Emitter-Base Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)		I_{EBO}	–	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain[1]		h_{FE}			–
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types		40	–	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2940		20	100	
(I_C = 4.0 Adc, V_{CE} = 2.0 Vdc)	MJ2941		20	100	
Base-Emitter On Voltage[1]		$V_{BE(on)}$			Vdc
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)	MJ2940		–	1.3	
(I_C = 4.0 Adc, V_{CE} = 3.0 Vdc)	MJ2941		–	1.4	
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc, f = 1.0 kHz)		f_T	4.0	20	MHz

[1]Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

FIGURE 2 – DC CURRENT GAIN

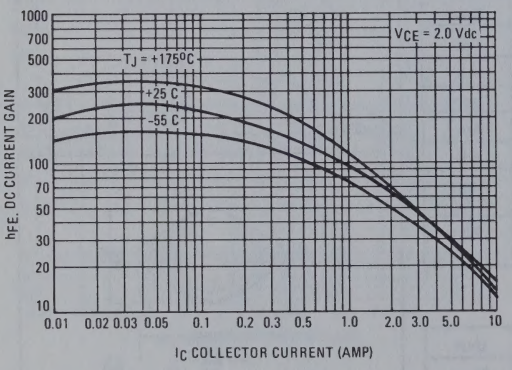


FIGURE 3 – "ON" VOLTAGES

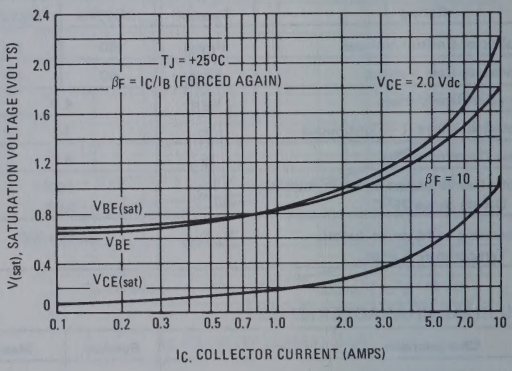
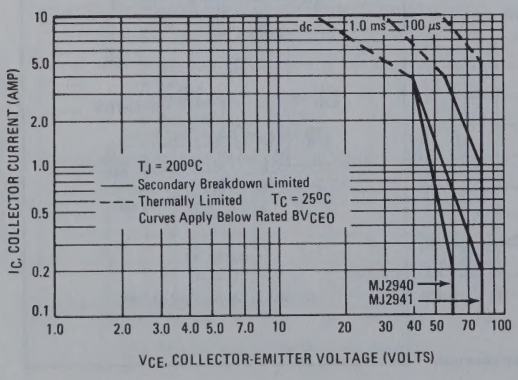


FIGURE 4 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C–V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.

MJE341 (SILICON)
MJE344

PLASTIC NPN SILICON
MEDIUM-POWER TRANSISTORS

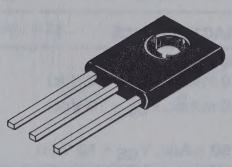
. . . designed for power output stages in television, radio, phonograph and other consumer product applications.

- Recommended for 1.5 W Class A Output in Transformer Coupled, Line-Operated Equipment – MJE341
- Ideal for Audio Output Circuitry in Black and White Television Receivers – MJE344

0.5 AMPERE
POWER TRANSISTORS

NPN SILICON

150–200 VOLTS
20.8 WATTS



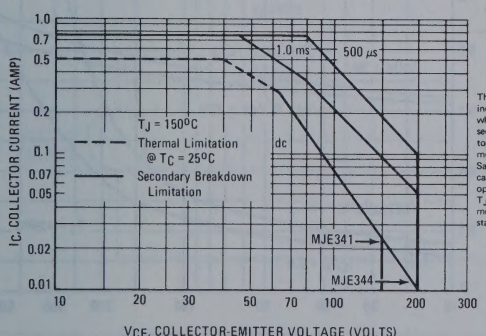
MAXIMUM RATINGS

Rating	Symbol	MJE341	MJE344	Unit
Collector-Emitter Voltage	V_{CEO}	150	200	Vdc
Collector-Base Voltage	V_{CB}	175	200	Vdc
Emitter-Base Voltage	V_{EB}	3.0	5.0	Vdc
Collector Current – Continuous	I_C	500		mAdc
Base Current	I_B	250		mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20.8 0.167		Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +150		^oC

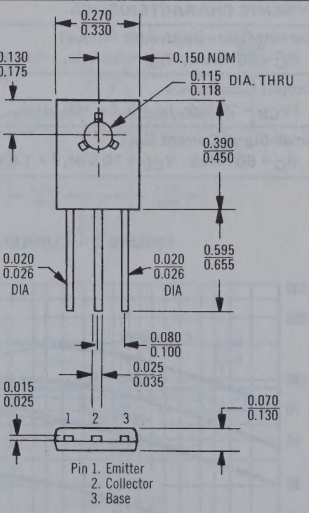
THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	6.0	$^oC/W$

FIGURE 1 – ACTIVE-REGION SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not enter secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a catastrophic failure. To insure operation below the maximum T_J, power-temperature derating must be observed for both steady state and pulse power conditions.



Pin 1. Emitter
2. Collector
3. Base

When mounting the device, torque not to exceed 6.0 in.-lb.

If lead bending is required, use suitable clamps or other supports between transistor case and point of bend.

CASE 77-02

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 1.0 mAdc, I_B = 0)	MJE341 MJE344	$V_{CEO(sus)}$	 150 200	 – –	Vdc
Collector Cutoff Current (V_{CE} = 150 Vdc, I_B = 0) (V_{CE} = 200 Vdc, I_B = 0)	 MJE341 MJE344	I_{CEO}	 – –	 1.0 1.0	mAdc
Collector Cutoff Current (V_{CB} = 175 Vdc, I_E = 0) (V_{CB} = 200 Vdc, I_E = 0)	 MJE341 MJE344	I_{CBO}	 – –	 0.3 0.1	mAdc
Emitter Cutoff Current (V_{EB} = 3.0 Vdc, I_C = 0) (V_{EB} = 5.0 Vdc, I_C = 0)	 MJE341 MJE344	I_{EBO}	 – –	 0.1 0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 50 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	 MJE341 MJE341 MJE344 MJE341	h_{FE}	 20 25 30 20	 – 200 300 –	–
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc)	 Both Types MJE341	$V_{CE(sat)}$	 – –	 1.0 2.3	Vdc
Base-Emitter On Voltage (I_C = 50 mAdc, V_{CE} = 10 Vdc)		$V_{BE(on)}$	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 25 Vdc, f = 10 MHz)		f_T	15	–	MHz
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f ≅ 100 kHz)		C_{ob}	–	15	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{fe}	25	–	–

FIGURE 2 – CURRENT GAIN

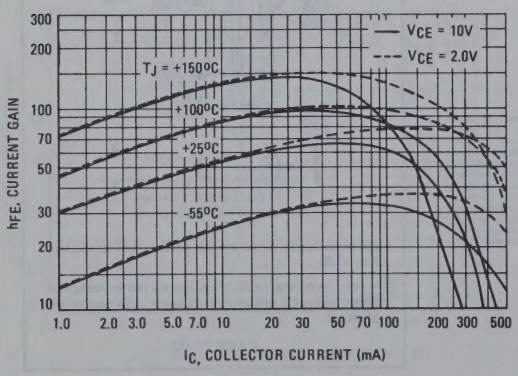
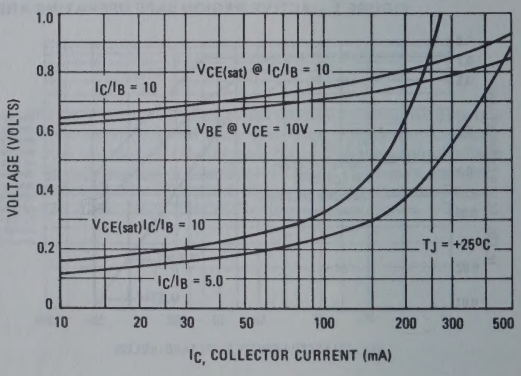


FIGURE 3 – "ON" VOLTAGES



MLED600

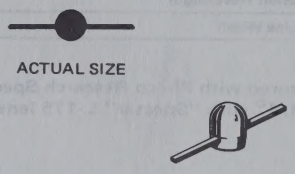
VISIBLE RED LIGHT-EMITTING DIODE

. . . designed for applications requiring high visibility, low drive power and very fast response time. This device is used in panel and circuit condition indicators, light modulators, shaft or position encoders, punched card readers, optical switching, and logic circuits.

- High Brightness – 300 fL (Typ)
- Visible Red Emission – 660 nm (Typ)
- Low Drive Current – 10 mA for 50 fL
- Unique Molded Lens for Durability and Long Life
- Economical Plastic Package

LIGHT-EMITTING DIODE
VISIBLE RED
PN GALLIUM ARSENIDE PHOSPHIDE

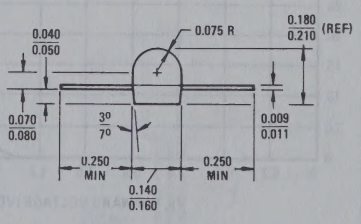
100 MILLIWATTS

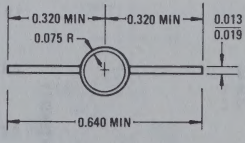


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	4.0	Volts
Forward Current-Continuous	I_F	50	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D(1)	100 1.67	mW mW/^oC
Operating Junction Temperature Range	T_J	-40 to +85	^oC
Storage Temperature Range	T_{stg}	-40 to +100	^oC

(1) Printed Circuit Board Mounting

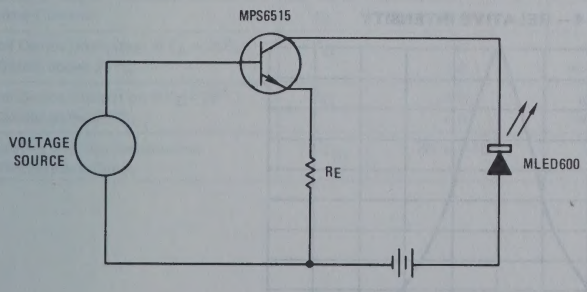




CASE 171(2)

(2) Cathode indicated by square bonding pad on bottom of device.

FIGURE 1 – TYPICAL DRIVE CIRCUIT



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Reverse Leakage Current (V_R = 4.0 V, R_L = 1.0 Megohm)	–	I_R	–	100	–	nA
Reverse Breakdown Voltage (I_R = 10 μA)	–	BV_R	4.0	–	–	Volts
Forward Voltage (I_F = 20 mA)	2	V_F	–	1.5	1.8	Volts
Total Capacitance (V_R = 0 V, f = 1.0 MHz)	–	C_T	–	150	–	pF

OPTICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Fig. No.	Symbol	Min	Typ	Max	Unit
Brightness (Note 1)	3	B				fL
(I_F = 10 mA)			50	–	–	
(I_F = 20 mA)			–	300	–	
Peak Emission Wavelength	4	λ_P	–	660	–	nm
Spectral Line Width	4	$\Delta\lambda$	–	20	–	nm

NOTE:

1. Measured with Photo Research Spectra Spot Brightness Meter Model UB 1/4° with "Spectar" L-175 lens.

FIGURE 2 – FORWARD CHARACTERISTICS

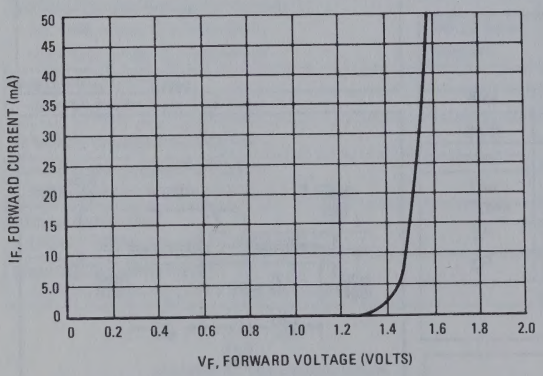


FIGURE 3 – BRIGHTNESS

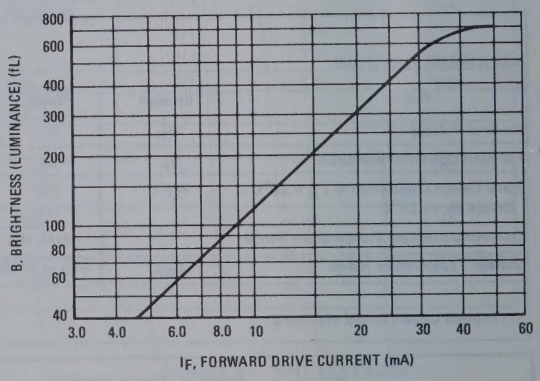
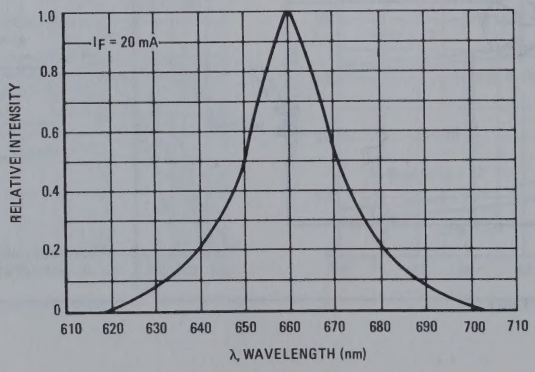


FIGURE 4 – RELATIVE INTENSITY



MM404 (GERMANIUM)
MM404A

PNP GERMANIUM SWITCHING TRANSISTORS

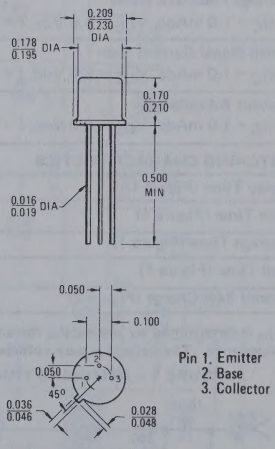
. . . designed for medium-speed saturated switching applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.2 Vdc (Max) @ I_C = 24 mAdc
- High Emitter-Base Breakdown Voltage –
  BV_{EBO} = 12 Vdc (Min) @ I_E = 20 μAdc – MM404
  = 25 Vdc (Min) @ I_E = 20 μAdc – MM404A

PNP GERMANIUM SWITCHING TRANSISTORS

MAXIMUM RATINGS

Rating	Symbol	MM404	MM404A	Unit
Collector-Emitter Voltage	V_{CES}	24	35	Vdc
Collector-Base Voltage	V_{CB}	25	40	Vdc
Emitter-Base Voltage	V_{EB}	12	25	Vdc
Collector Current – Continuous	I_C	150		mAdc
Emitter Current	I_E	100		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2.0		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4.0		mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +100		°C



CASE 22 (1)
TO-18

MM404, MM404A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 20 μAdc, I_E = 0)	MM404	BV_{CBO}	25	–	–	Vdc
	MM404A		40	–	–	
Emitter-Base Breakdown Voltage (I_E = 20 μAdc, I_C = 0)	MM404	BV_{EBO}	12	–	–	Vdc
	MM404A		25	–	–	
Punch-Through Voltage(1) (V_{EBfl} = 1.0 Vdc)	MM404	V_{pt}	24	–	–	Vdc
	MM404A		35	–	–	
Emitter-Base Floating Potential (V_{CB} = 35 Vdc, I_E = 0)	MM404A	V_{EBfl}	–	–	1.0	Vdc
Collector Cutoff Current (V_{CB} = 12 Vdc, I_E = 0)		I_{CBO}	–	0.8	5.0	μAdc
(V_{CB} = 12 Vdc, I_E = 0, T_A = 80°C)			–	20	90	
Emitter Cutoff Current (V_{EB} = 2.5 Vdc, I_C = 0)		I_{EBO}	–	0.5	2.5	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 12 mAdc, V_{CE} = 0.15 Vdc)		h_{FE}	30	80	–	–
(I_C = 24 mAdc, V_{CE} = 0.20 Vdc)			24	90	–	
Collector-Emitter Saturation Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc)		$V_{CE(sat)}$	–	0.09	0.15	Vdc
(I_C = 24 mAdc, I_B = 1.0 mAdc)			–	0.09	0.20	
Base-Emitter Voltage (I_C = 12 mAdc, I_B = 0.4 mAdc)		V_{BE}	–	0.27	0.35	Vdc
(I_C = 24 mAdc, I_B = 1.0 mAdc)			–	0.30	0.40	
SMALL-SIGNAL CHARACTERISTICS						
Alpha Cutoff Frequency (I_E = 1.0 mAdc, V_{CB} = 6.0 Vdc)		f_{hfb}	4.0	25	–	MHz
Output Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 1.0 MHz)	MM404	C_{ob}	–	8.0	20	pF
(V_{CB} = 6.0 Vdc, I_E = 1.0 mAdc, f = 2.0 MHz)	MM404A		–	8.0	20	
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{ie}	–	3.0	–	k ohms
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{re}	–	8.0	–	X 10^{-4}
Small-Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{fe}	–	135	–	–
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, f = 1.0 kHz)		h_{oe}	–	50	–	μmhos
SWITCHING CHARACTERISTICS						
Delay Time (Figure 1)		t_d	–	0.07	–	μs
Rise Time (Figure 1)		t_r	–	0.12	–	μs
Storage Time (Figure 1)		t_s	–	0.20	–	μs
Fall Time (Figure 1)		t_f	–	0.10	–	μs
Stored Base Charge (Figure 2)		Q_{sb}	–	300	1400	pC

(1) V_{pt} is determined by measuring the emitter-base floating potential V_{EBfl}, using a voltmeter with 11 megohms minimum input impedance. The collector-base voltage, V_{CB}, is measured until V_{EBfl} = −1.0 Vdc; this value of V_{CB} = (V_{pt} + 1).

FIGURE 1 – SWITCHING TIMES TEST CIRCUIT

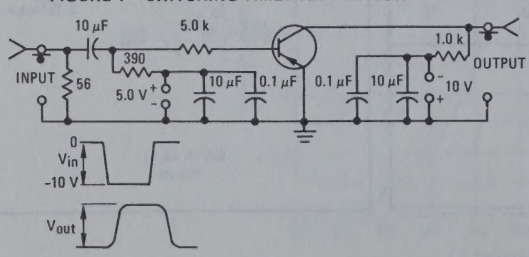
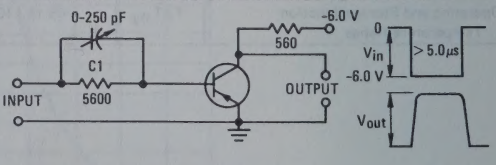


FIGURE 2 – STORED BASE CHARGE TEST CIRCUIT



C1 is increased until the t_{off} time of the output waveform is decreased to 0.2 μs. Q_{sb} is then calculated by Q_{sb} = C1 V_{in}.

NOTES: 1. Input pulse supplied by generator with following characteristics:
a. Output impedance: 50 Ohms
b. Repetition rate: 1.0 kHz
c. Rise and fall time: 20 ns Max
2. Waveforms monitored on scope with following characteristics:
a. Input resistance – 10 Megohms Min
b. Input capacitance – 15 pF Max
c. Rise time – 15 ns Max
3. All resistors ± 1.0% tolerance.

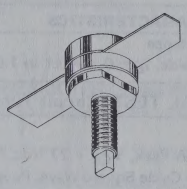
MM1552 (SILICON)

NPN SILICON RF POWER TRANSISTOR

. . . designed for VHF power amplifier applications in military and industrial equipment. Particularly suited for use in Class AB, B, or C amplifier applications to 175 MHz.

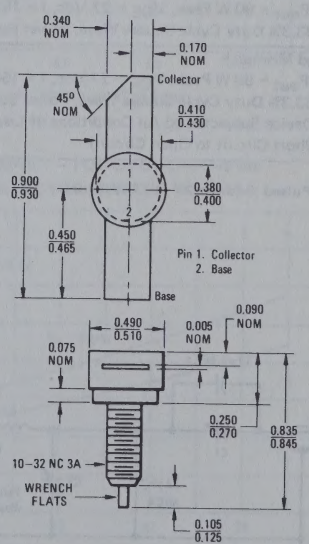
- High Output Power Capability –
  90 Watts Peak Output for 15 Watts (Typ) Input @ f = 150 MHz
- Balanced Emitter Construction to Provide the Designer with the device Technology that Assures Ruggedness and Resists Transistor Damage Caused by Load Mismatch.
- Stripline Packaging for Lower Lead Inductance and Better Broadband Capability

NPN SILICON RF POWER TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	8.0	Adc
Total Device Dissipation @ T_C=50°C Derate above 50°C	P_D	80 533	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C



Emitter Connected to Stud

CASE 145C – 01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

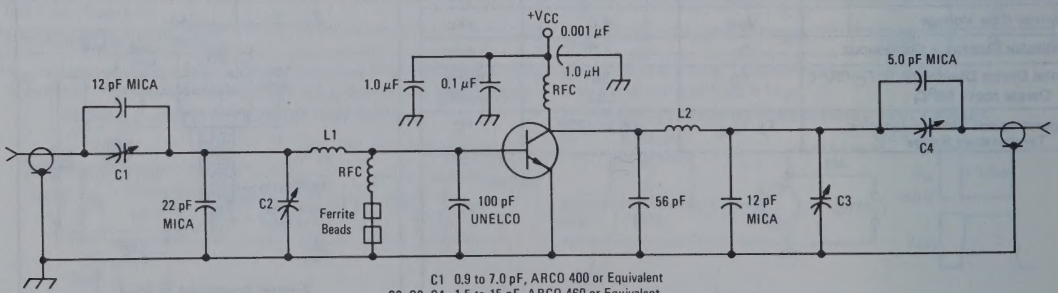
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ① (I_C = 200 mAdc, I_B = 0)	BV_{CEO}	35	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 200 mAdc, V_{BE} = 0)	BV_{CES}	65	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	–	–	2.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 3.0 Adc, V_{CE} = 5.0 Vdc)	h_{FE}	5.0	–	–	–
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 0.1 to 1.0 MHz)	C_{ob}	–	90	130	pF

FUNCTIONAL TEST (Circuit Tuned at 90 Watts Peak, V_{CE} = 27 Vdc and not retuned for 13.5 Vdc Carrier Power Test)

Power Input (P_{out} = 90 W Peak, V_{CE} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	$P_{in(peak)}$	–	15	18	Watts
Power Output CW (Carrier Power) (P_{in} = 7.7 W, V_{CE} = 13.5 Vdc, f = 150 MHz, Circuit Tuned at 90 W Peak, V_{CE} = 27 Vdc)	P_{out}	24	27	–	Watts
Power-Output CW (V_{CE} = 27 Vdc, f = 150 MHz, Saturated CW Output Power)	P_{out}	75	–	–	Watts
Collector Efficiency (P_{out} = 90 W Peak, V_{CE} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated)	η	60	–	–	%
Load Mismatch (P_{out} = 90 W Peak, V_{CE} = 27 Vdc, f = 150 MHz, 33.3% Duty Cycle Square Wave, Power Source Modulated. Device Subjected to All Conditions of Load Mismatch from Short-Circuit to Open Circuit)	Less Than 5% Change in Power Readings Before and After Mismatch Tests.				

① Pulsed through 25 mH Inductor.

FIGURE 1 – 150 MHz TEST CIRCUIT



C1 0.9 to 7.0 pF, ARCO 400 or Equivalent
C2, C3, C4 1.5 to 15 pF, ARCO 460 or Equivalent
L1 1" x 3/16" Straight Copper Strap 0.030 Thick
L2 1 1/2 Turns #16 AWG, 1/4" O.D.

FIGURE 2 – POWER OUTPUT versus FREQUENCY

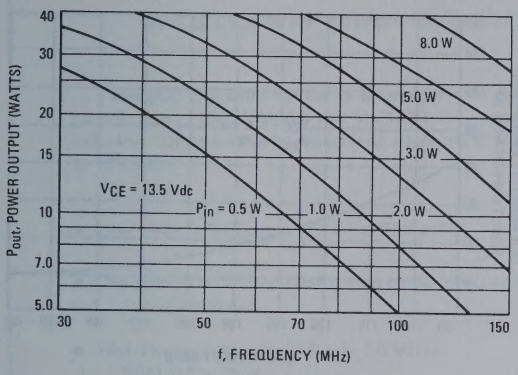


FIGURE 3 – POWER OUTPUT versus FREQUENCY

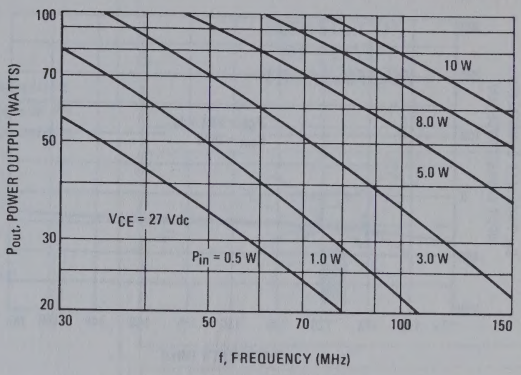


FIGURE 4 – POWER OUTPUT versus POWER INPUT

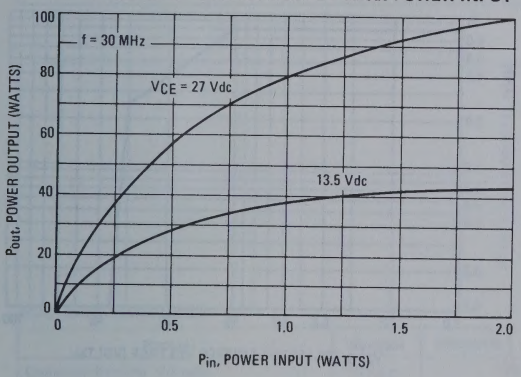


FIGURE 5 – POWER OUTPUT versus POWER INPUT

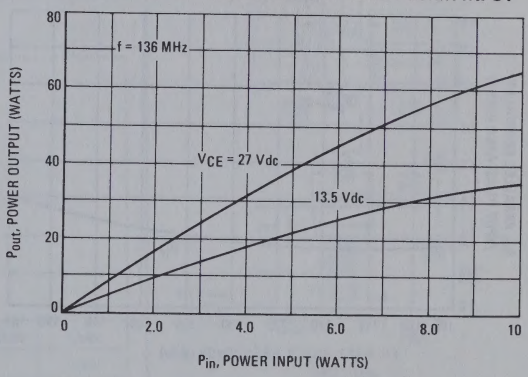


FIGURE 6 – POWER OUTPUT versus POWER INPUT

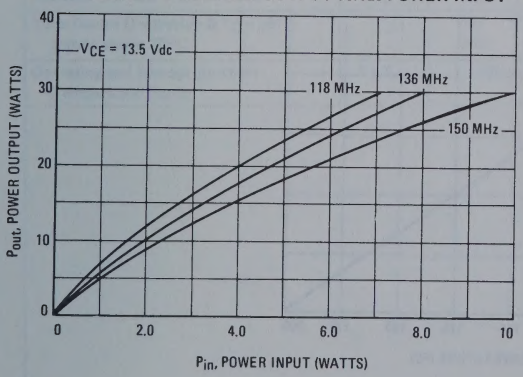


FIGURE 7 – POWER OUTPUT versus COLLECTOR-EMITTER VOLTAGE

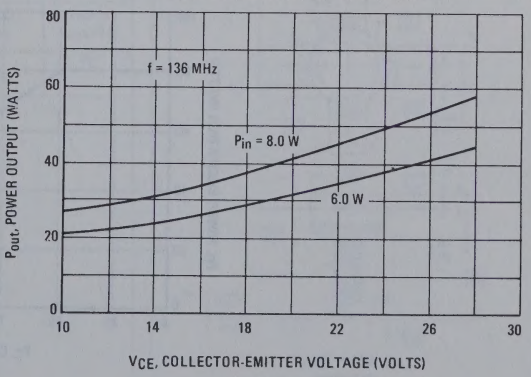


FIGURE 8 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

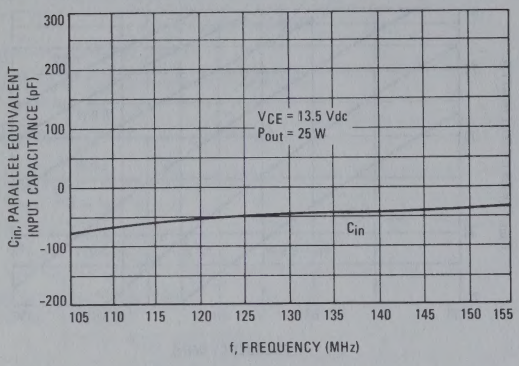


FIGURE 9 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

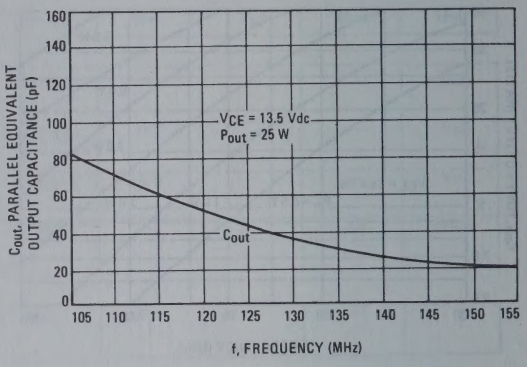


FIGURE 10 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

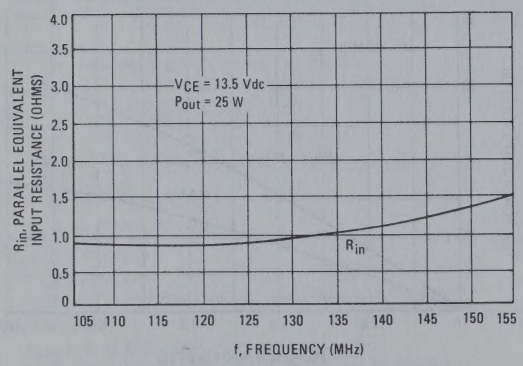


FIGURE 11 – DC SAFE OPERATING AREA

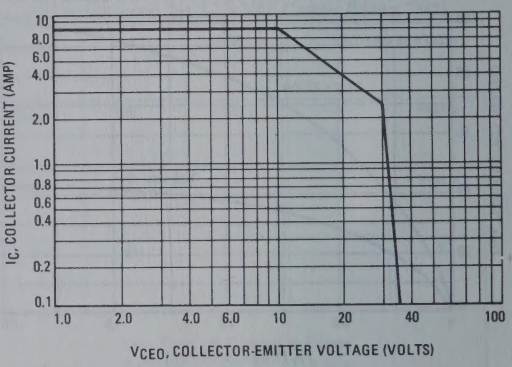
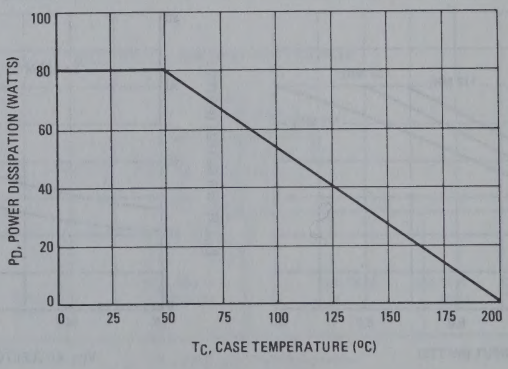


FIGURE 12 – POWER TEMPERATURE DERATING CURVE



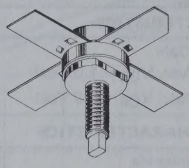
MM1619 (SILICON)
MM1620

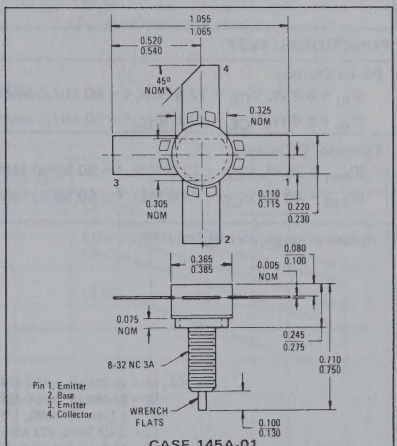
NPN SILICON RF POWER TRANSISTORS

. . . designed primarily for use in large signal low voltage amplifier output stages, the MM1619 and MM1620 are intended for use in industrial communications equipment operating in frequency ranges to 100 MHz.

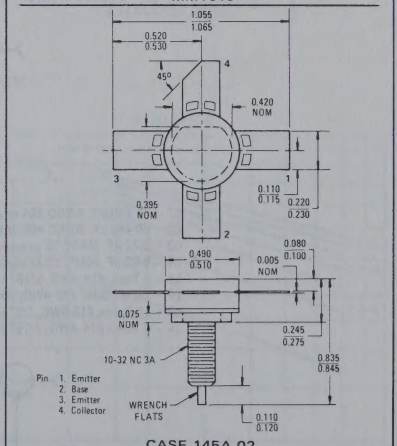
- Low Inductance Ceramic Stripline Packaging
- Designed to Withstand Destruction Under Open or Shorted Load Conditions
- High Power Output @ 12.5 Vdc, 50 MHz —
  MM1619 — 25 W
  MM1620 — 40 W

NPN SILICON RF POWER TRANSISTORS





CASE 145A-01
MM1619



CASE 145A-02
MM1620

MAXIMUM RATINGS

Rating	Symbol	MM1619	MM1620	Unit
Collector-Emitter Voltage	V_{CEO}	24		Vdc
Collector-Base Voltage	V_{CB}	48		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current — Continuous	I_C	3.5	7.0	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	50 285	100 571	Watts mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		^oC

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage(1) (I_C = 0.2 Adc, I_B = 0)		$V_{CEO(sus)}$	24	–	–	Vdc
Collector-Emitter Sustaining Voltage(1) (I_C = 0.1 Adc, R_{BE} = 0)		$V_{CES(sus)}$	48	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 mAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)		I_{CBO}	–	–	1.0	mAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	MM1619		3.0	–	–	
(I_C = 2.4 Adc, V_{CE} = 5.0 Vdc)	MM1620		3.0	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 12.5 Vdc, I_E = 0, f = 1.0 MHz)	MM1619		–	65	100	
	MM1620		–	150	230	
FUNCTIONAL TEST						
Power Output		P_{out}				Watts
(P_{in} = 3.0 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1619, Figure 1			25	–	–	
(P_{in} = 6.0 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1620, Figure 2			40	–	–	
Collector Efficiency		η				%
(P_{out} = 25 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1619, Figure 1			50	–	–	
(P_{out} = 40 W, V_{CE} = 12.5 Vdc, f = 50 MHz) MM1620, Figure 2			50	–	–	

(1) Pulsed through 25 mH Inductor.

50 MHz TEST CIRCUITS

FIGURE 1 – MM1619

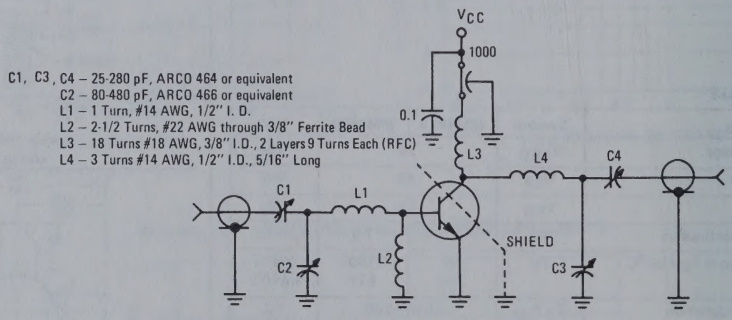
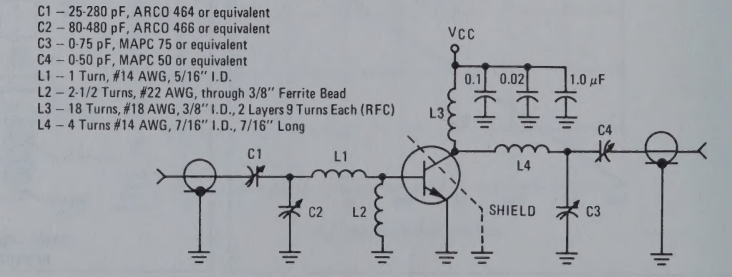

C1, C3, C4 – 25-280 pF, ARCO 464 or equivalent
C2 – 80-480 pF, ARCO 466 or equivalent
L1 – 1 Turn, #14 AWG, 1/2" I. D.
L2 – 2-1/2 Turns, #22 AWG through 3/8" Ferrite Bead
L3 – 18 Turns #18 AWG, 3/8" I.D., 2 Layers 9 Turns Each (RFC)
L4 – 3 Turns #14 AWG, 1/2" I.D., 5/16" Long
VCC
1000
0.1
L3
L4
C4
C1
L1
SHIELD
L2
C2
C3

FIGURE 2 – MM1620


C1 – 25-280 pF, ARCO 464 or equivalent
C2 – 80-480 pF, ARCO 466 or equivalent
C3 – 0-75 pF, MAPC 75 or equivalent
C4 – 0-50 pF, MAPC 50 or equivalent
L1 – 1 Turn, #14 AWG, 5/16" I.D.
L2 – 2-1/2 Turns, #22 AWG, through 3/8" Ferrite Bead
L3 – 18 Turns, #18 AWG, 3/8" I.D., 2 Layers 9 Turns Each (RFC)
L4 – 4 Turns #14 AWG, 7/16" I.D., 7/16" Long
VCC
0.1
0.02
1.0 μF
L3
C4
C1
L1
L4
C2
L2
SHIELD
C3

POWER OUTPUT versus POWER INPUT

FIGURE 3

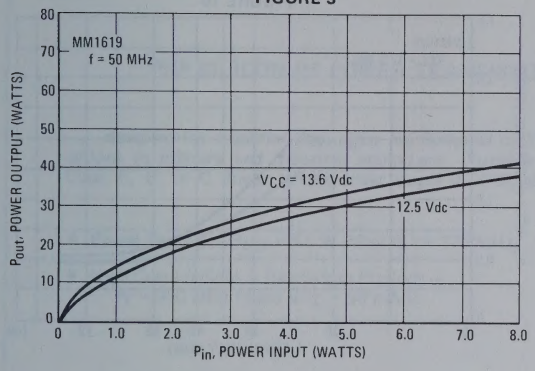
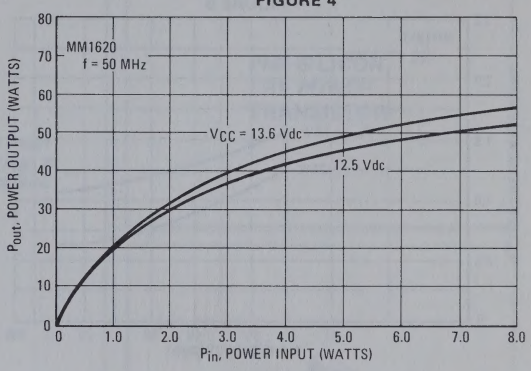


FIGURE 4



POWER OUTPUT versus FREQUENCY

FIGURE 5

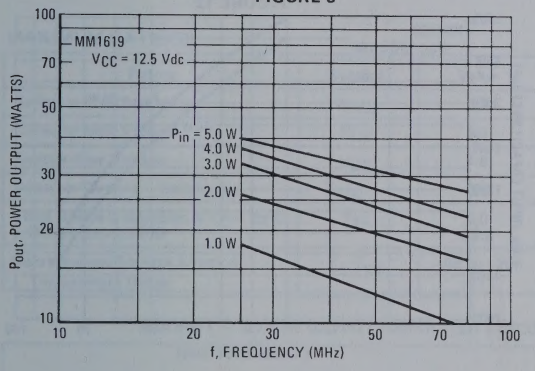
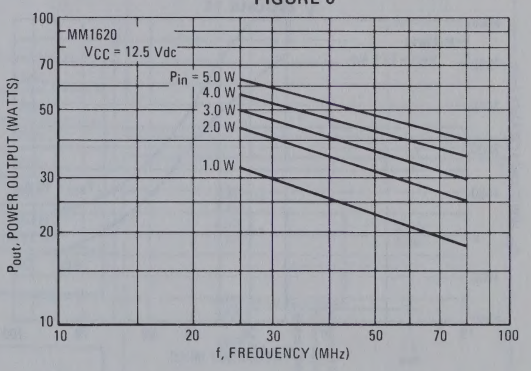


FIGURE 6



POWER OUTPUT versus FREQUENCY

FIGURE 7

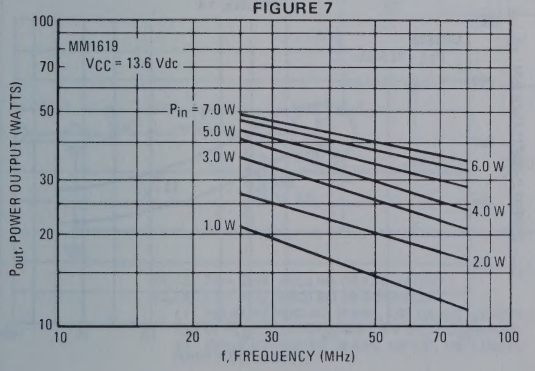
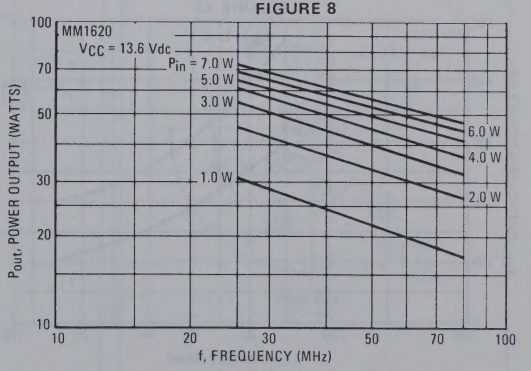


FIGURE 8



PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 9

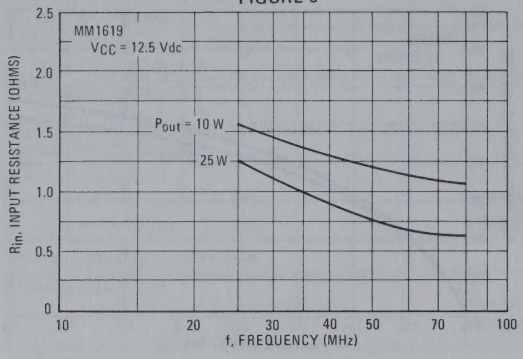
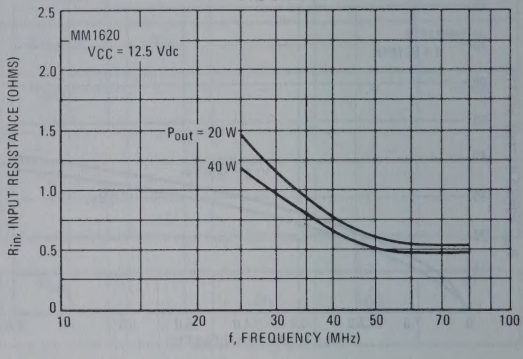


FIGURE 10



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 11

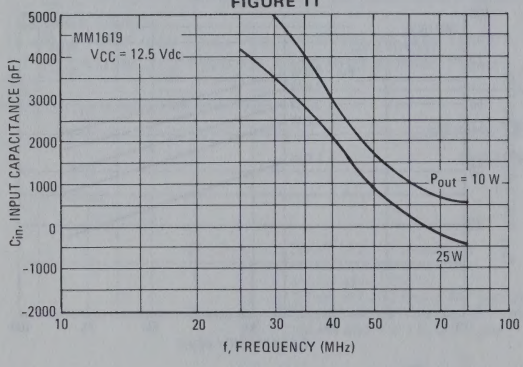
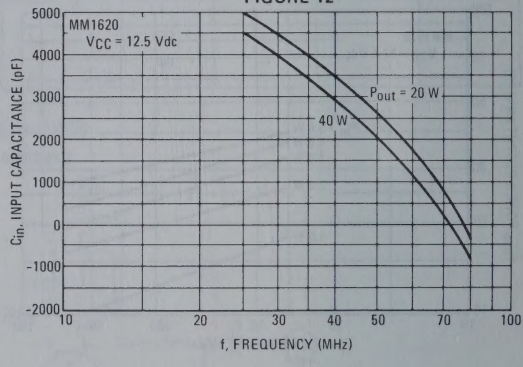


FIGURE 12



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

FIGURE 13

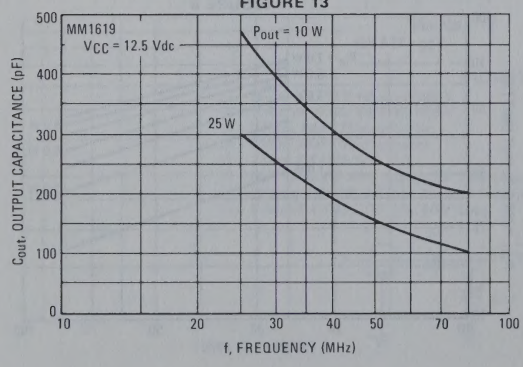
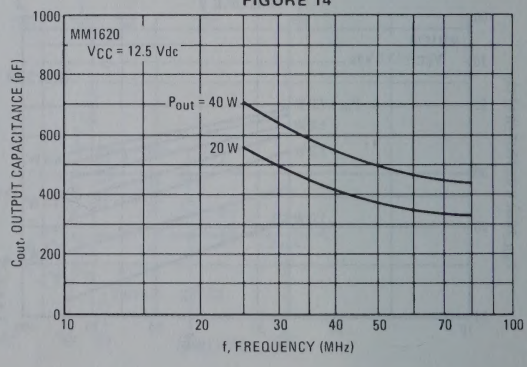


FIGURE 14



MM4018 (SILICON)

PNP SILICON RF POWER TRANSISTOR

. . . designed for amplifier, frequency multiplier or oscillator applications in military and industrial equipment. Suitable for use as Class A, B, or C driver, or pre-driver stages in VHF applications.

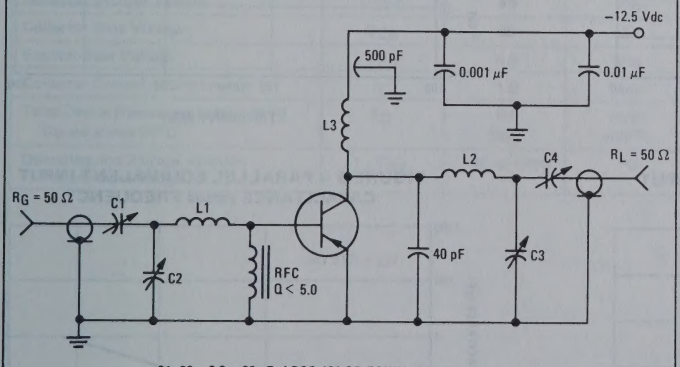
- Power Output – P_{out} = 0.5 W (Min) @ f = 175 MHz
- High Current-Gain – Bandwidth Product – f_T = 900 MHz (Typ) @ I_C = 50 mAdc

PNP SILICON RF POWER TRANSISTOR

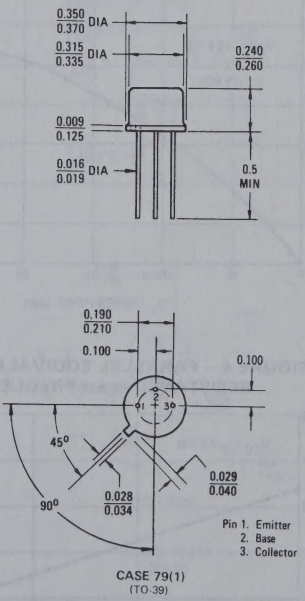
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	0.4	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	−65 to +200	°C

FIGURE 1 – 175 MHz OUTPUT POWER TEST CIRCUIT



C1, C2 3.0 – 30 pF, ARCO 461 OR EQUIVALENT
C3, C4 8.0 – 80 pF, ARCO 462 OR EQUIVALENT
L1 100 nH, 4 TURNS NO. 18 AWG, 1/4" I.D., 5/8" LENGTH
L2 40 nH, 2 TURNS NO. 18 AWG, 1/4" I.D., 1/2" LENGTH
L3 200 nH, 8 TURNS NO. 18 AWG, 1/4" I.D., 7/8" LENGTH



CASE 79(1)
(TO-39)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 5.0 mAdc, I_B = 0)	BV_{CEO}	20	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 5.0 mAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 1.0 mAdc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, I_B = 0)	I_{CEO}	–		20	μAdc
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{BE} = 0)	I_{CES}	–	–	0.1	mAdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0)	I_{CBO}	–	–	10	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	f_T	–	900	–	MHz
Output Capacitance (V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	3.5	–	pF
FUNCTIONAL TEST					
Power Output (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	P_{out}	0.5	–	–	Watt
Collector Efficiency (Figure 1) (P_{in} = 50 mW, V_{CC} = 12.5 Vdc, f = 175 MHz)	η	45	55	–	%

FIGURE 2 – POWER OUTPUT versus POWER INPUT

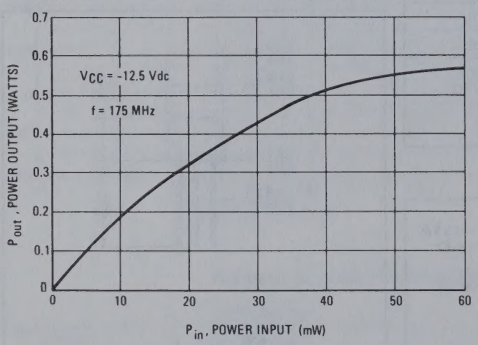


FIGURE 3 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

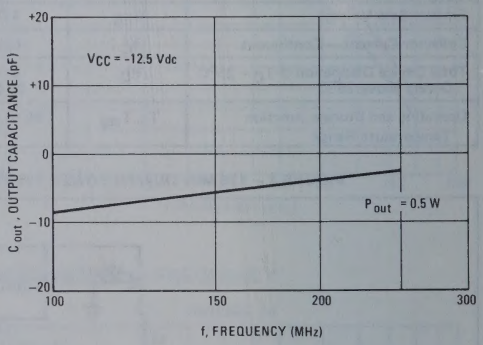


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

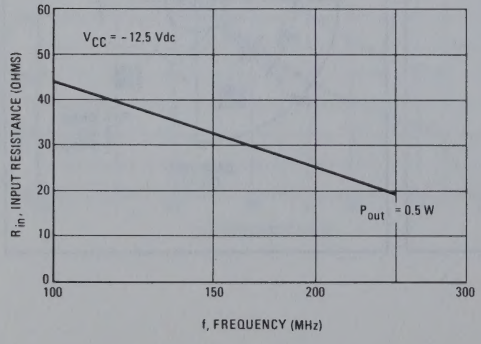
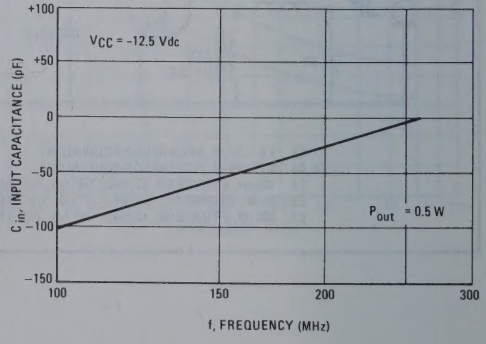


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY



MM4019 (SILICON)

PNP SILICON RF POWER TRANSISTOR

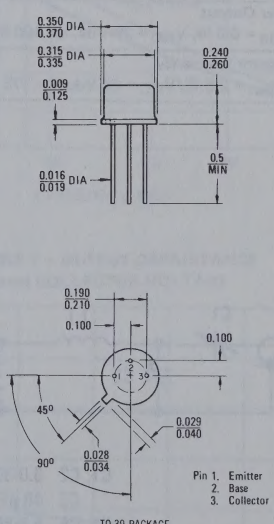
. . . designed for use as complement to NPN 2N3553 in VHF and UHF amplifier applications for military and industrial equipment.

- Power Output – P_{out} = 2.0 W (Typ) @ P_{in} = 0.5 W, f = 400 MHz
- Power Input – P_{in} = 0.25 W (Max) @ P_{out} = 2.5 W, f = 175 MHz

PNP SILICON RF POWER TRANSISTOR

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current – Continuous	I_C	1.0	Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C



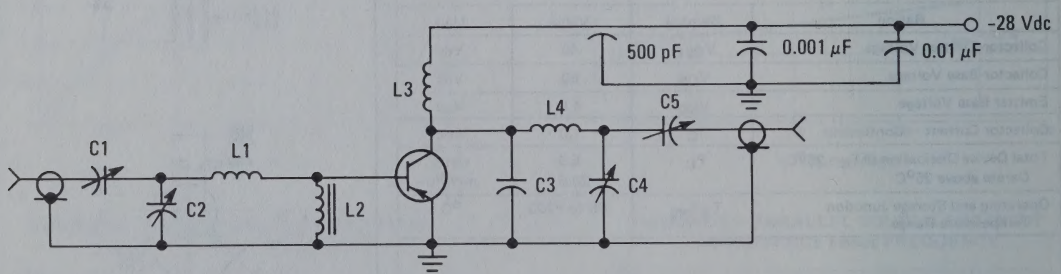
TO-39 PACKAGE

CASE 79(1)
(TO-39)

ELECTRICAL CHARACTERISTICS (T_A = 25° unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 10 mAdc, I_E = 0)	BV_{CBO}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 Adc, I_C = 0)	BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	–	–	0.1	mAdc
Emitter Cutoff Current (V_{BE} = 4.0 Vdc, I_C = 0)	I_{EBO}	–	–	0.1	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 250 mAdc, V_{CE} = 5.0 Vdc)	h_{FE}	10	–	–	–
Collector-Emitter Saturation Voltage (I_C = 250 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	–	750	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	7.5	–	pF
FUNCTIONAL TEST					
Power Input (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	P_{in}	–	–	0.25	Watt
Power Output (P_{in} = 0.5 W, V_{CC} = 28 Vdc, f = 400 MHz)	P_{out}	–	2.0	–	Watts
Collector Efficiency (P_{out} = 2.5 W, V_{CC} = 28 Vdc, f = 175 MHz)	η	50	–	–	%

FIGURE 1 – 175 MHz TEST CIRCUIT



C1, C2 3.0-30 pF, ARCO 461 or equivalent.
C3 40 pF
C4, C5 5.0-80 pF, ARCO 462 or equivalent.
L1 80 nH, 3 Turns #18 AWG, 1/4" I.D., 1/4" Length
L2 Ferrite Choke, VK-200 Ferroxcube, Q < 5
L3 0.15 μH, RF Choke
L4 27 nH, 2 Turns #18 AWG, 1/4" I.D., 3/8" Length

FIGURE 2 – POWER OUTPUT versus FREQUENCY

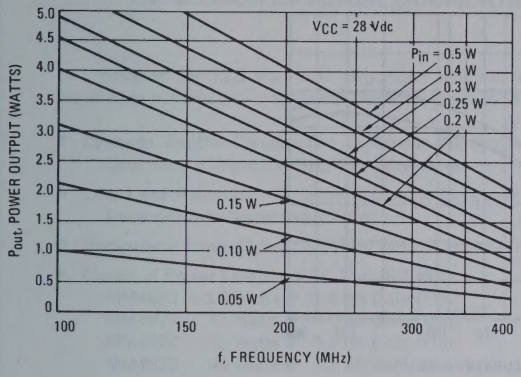


FIGURE 3 – POWER OUTPUT versus POWER INPUT

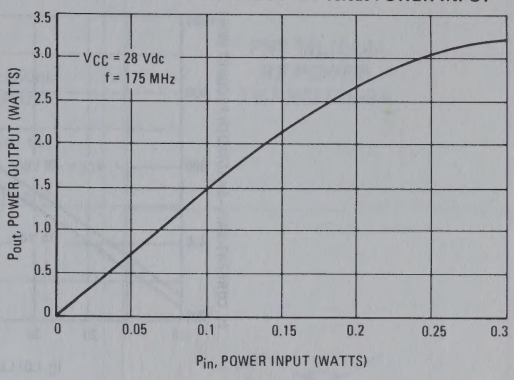


FIGURE 4 – PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

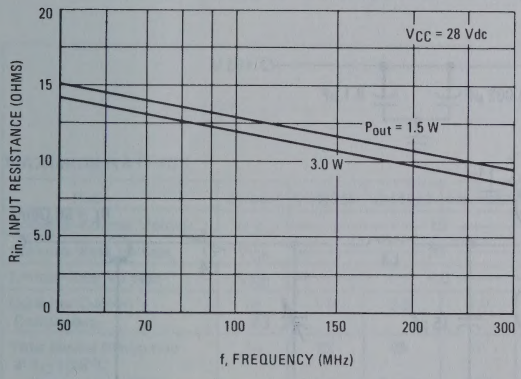


FIGURE 5 – PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

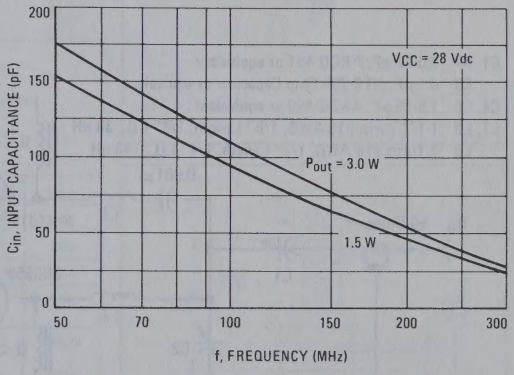


FIGURE 6 – PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

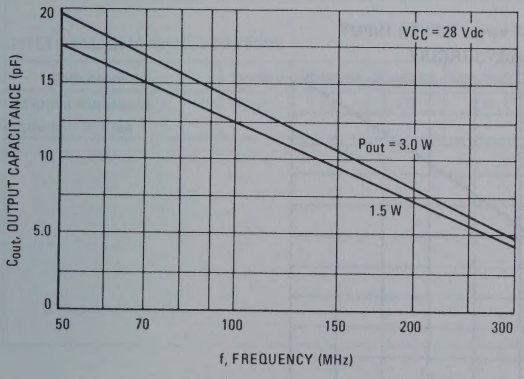


FIGURE 7 – OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

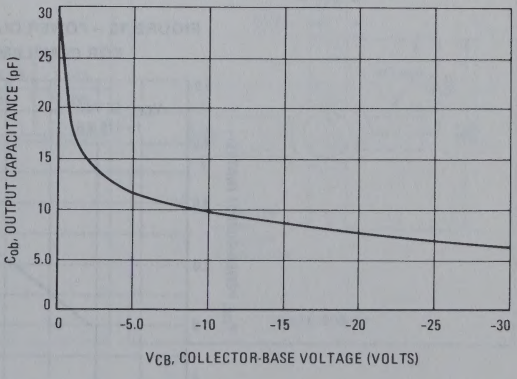


FIGURE 8 – CURRENT-GAIN–BANDWIDTH PRODUCT

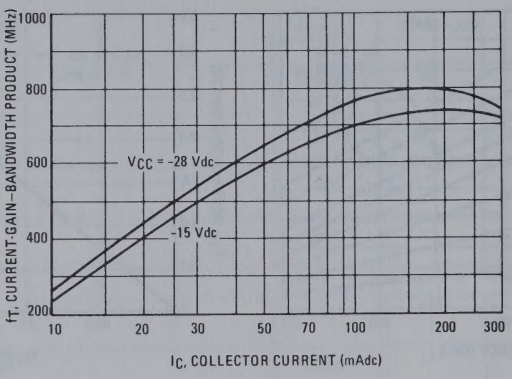


FIGURE 9 – MM4019/2N3553 COMPLEMENTARY 175 MHz AMPLIFIER CIRCUIT

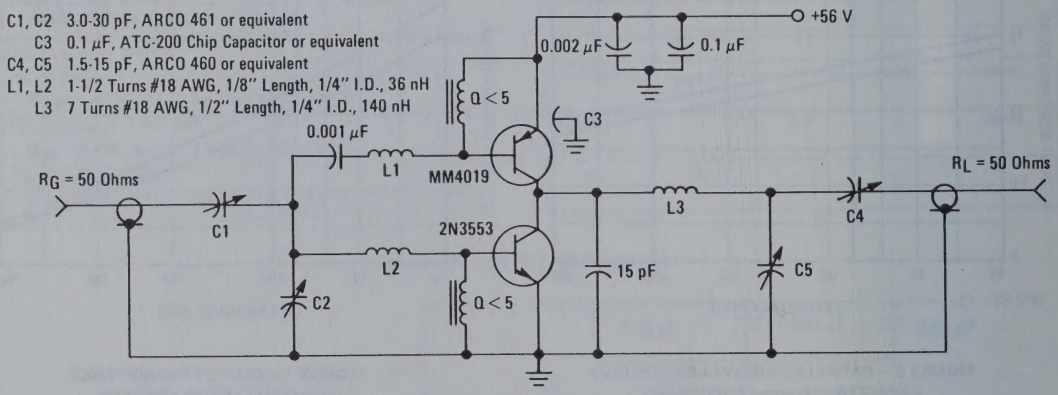
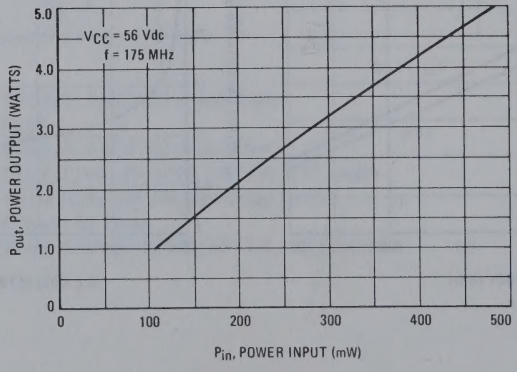


FIGURE 10 – POWER OUTPUT versus POWER INPUT FOR COMPLEMENTARY CIRCUIT



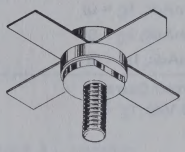
MM4020 (SILICON)
thru
MM4023

PNP SILICON RF POWER TRANSISTORS

. . . designed for 12.5 Volt VHF large-signal amplifier applications required in military and industrial equipment operating to 250 MHz.

- Balanced Emitter Construction to Provide the Designer with the Optimum in Transistor Safe Operating Area
- Low Lead Inductance Stripline Packaging for Easier Design and Increased Broadband Capabilities
- Exceptional Power Output Stability versus Temperature
- Choice of Power Levels at 12.5 Vdc, 175 MHz
  MM4020 – 3.5 Watts @ 11.5 dB Gain (Min)
  MM4021 – 15 Watts @ 7.0 dB Gain (Min)
  MM4022 – 25 Watts @ 5.5 dB Gain (Min)
  MM4023 – 40 Watts @ 4.5 dB Gain (Min)

PNP SILICON RF POWER TRANSISTORS

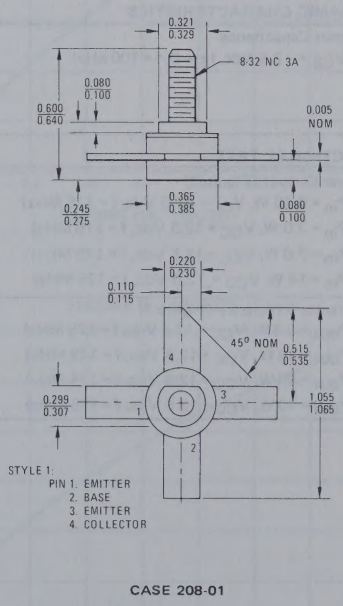


MAXIMUM RATINGS

Rating	Symbol	MM4020	MM4021	MM4022	MM4023	Unit
Collector-Emitter Voltage	V_{CEO}	← 18 →				Vdc
Collector-Base Voltage	V_{CB}	← 36 →				Vdc
Emitter-Base Voltage	V_{EB}	← 4.0 →				Vdc
Collector Current – Continuous	I_C	1.0	2.5	4.0	6.0	Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	25	29	70	87	Watts
Derate above 25^oC		0.2	0.232	0.56	0.696	$W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +150 →				^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	MM4020	MM4021	MM4022	MM4023	Unit
Thermal Resistance, Junction to Case	θ_{JC}	7.0	6.0	2.5	2.0	$^oC/W$

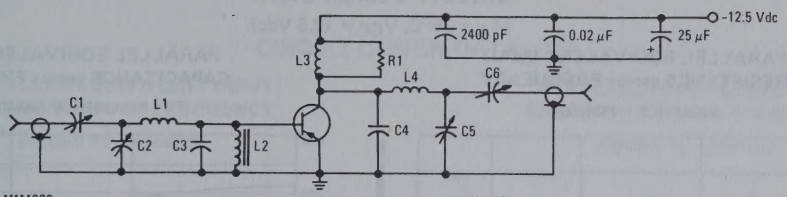


CASE 208-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 10 mAdc, I_B = 0)	MM4020		18	–	–	
(I_C = 20 mAdc, I_B = 0)	MM4021		18	–	–	
(I_C = 50 mAdc, I_B = 0)	MM4022		18	–	–	
(I_C = 100 mAdc, I_B = 0)	MM4023		18	–	–	
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 5.0 mAdc, I_E = 0)	MM4020		36	–	–	
(I_C = 10 mAdc, I_E = 0)	MM4021		36	–	–	
(I_C = 15 mAdc, I_E = 0)	MM4022		36	–	–	
(I_C = 20 mAdc, I_E = 0)	MM4023		36	–	–	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 1.0 mAdc, I_C = 0)	MM4020		4.0	–	–	
(I_E = 2.0 mAdc, I_C = 0)	MM4021		4.0	–	–	
(I_E = 5.0 mAdc, I_C = 0)	MM4022		4.0	–	–	
(I_E = 10 mAdc, I_C = 0)	MM4023		4.0	–	–	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 15 Vdc, I_E = 0)	MM4020		–	–	50	
	MM4021		–	–	100	
	MM4022		–	–	250	
	MM4023		–	–	500	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 0.25 Adc, V_{CE} = 5.0 Vdc)	MM4020		15	–	–	
(I_C = 0.5 Adc, V_{CE} = 5.0 Vdc)	MM4021,MM4022,MM4023		15	–	–	
DYNAMIC CHARACTERISTICS						
Output Capacitance		C_{ob}				pF
(V_{CB} = 12.5 Vdc, I_E = 0, f = 100 kHz)	MM4020		–	15.5	–	
	MM4021		–	90	–	
	MM4022		–	130	–	
	MM4023		–	180	–	
FUNCTIONAL TEST						
Power Output (Figure 1)		P_{out}				Watts
(P_{in} = 0.25 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4020		3.5	–	–	
(P_{in} = 3.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4021		15	–	–	
(P_{in} = 7.0 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4022		25	–	–	
(P_{in} = 14 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4023		40	–	–	
Collector Efficiency (Figure 1)		η				%
(P_{out} = 3.5 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4020		50	–	–	
(P_{out} = 15 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4021		55	–	–	
(P_{out} = 25 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4022		60	–	–	
(P_{out} = 40 W, V_{CC} = 12.5 Vdc, f = 175 MHz)	MM4023		50	–	–	

FIGURE 1 – 175 MHz TEST CIRCUIT



MM4020
C1,C2,C5,C6 5.0-80 pF, ARCO 462 or equivalent
C3 7.0 pF
C4 7.0 pF
L1 25 nH, 1 Turn #18 AWG, 1/4" Length, 1/4" I.D.
L2 Ferrite Choke VK-200 Ferroxcube.
L3 150 nH, 8 Turns #18 AWG, 3/4" Length, 3/16" I.D.
L4 36 nH, 1-1/2 Turns, #18 AWG, 1/4" Length, 1/4" I.D.
R1 330 Ohms

MM4021
C1,C2,C5,C6 9.0-180 pF, ARCO 463 or equivalent
C3 120 pF
C4 40 pF
L1 18 nH, 1-1/4" Straight #16 AWG
L2 Ferrite Choke VK-200 Ferroxcube.
L3 150 nH, 8 Turns #18 AWG, 3/4" Length, 3/16" I.D.
L4 25 nH, 1 Turn, #18 AWG, 14" Length, 1/4" I.D.
R1 330 Ohms

MM4022, MM4023
C1,C2,C5,C6 5.0-80 pF, ARCO 462 or equivalent
C3 100 pF
C4 100 pF
L1 18 nH, 1-1/4" Straight #16 AWG
L2 Ferrite Choke VK-200, Ferroxcube.
L3 150 nH, 8 Turns #18 AWG, 3/4" Length, 3/16" I.D.
L4 25 nH, 1 Turn #18 AWG, 1/4" Length, 1/4" I.D.
R1 330 Ohms

TYPICAL PERFORMANCE DATA

POWER OUTPUT versus POWER INPUT

(T_A = 25°C, V_{CC} = 12.5 Vdc, f = 175 MHz)

FIGURE 2 – MM4020

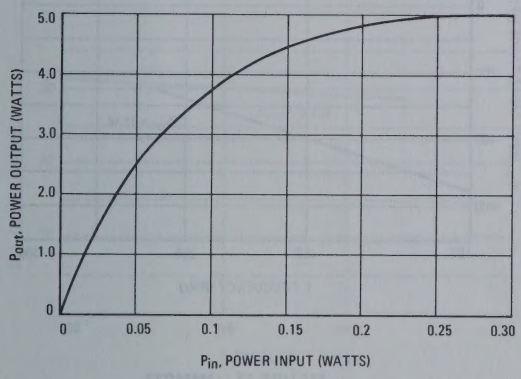


FIGURE 3 – MM4021

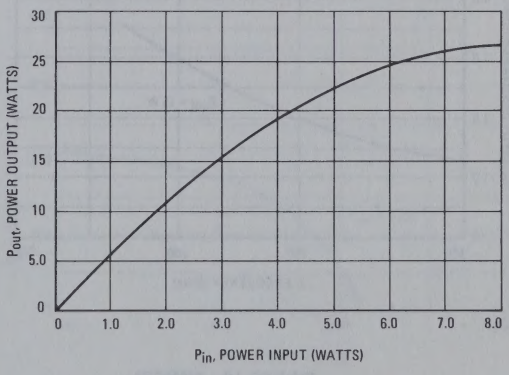


FIGURE 4 - MM4022

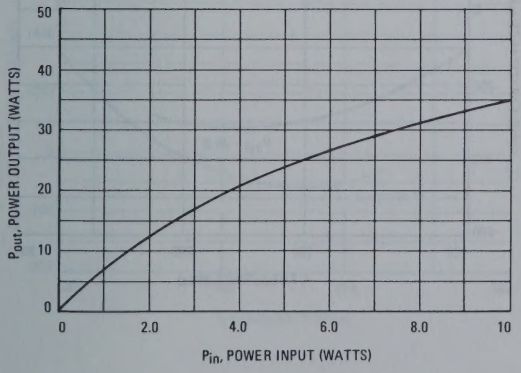
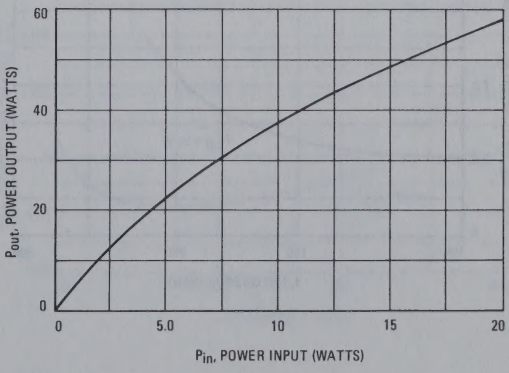


FIGURE 5 – MM4023

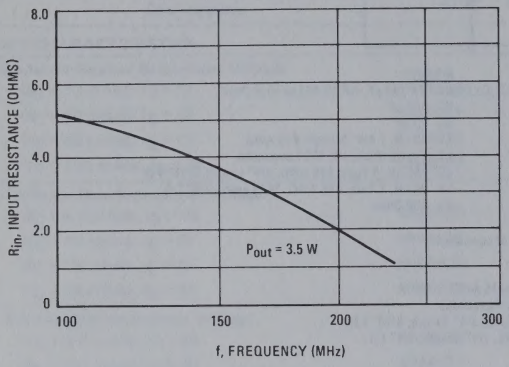


CIRCUIT DESIGN DATA

(T_A = 25°C, V_{CC} = 12.5 Vdc)

PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 6 – MM4020



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 7 – MM4020

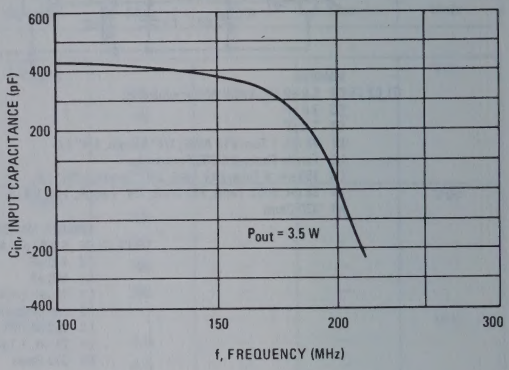


FIGURE 8 – MM4021

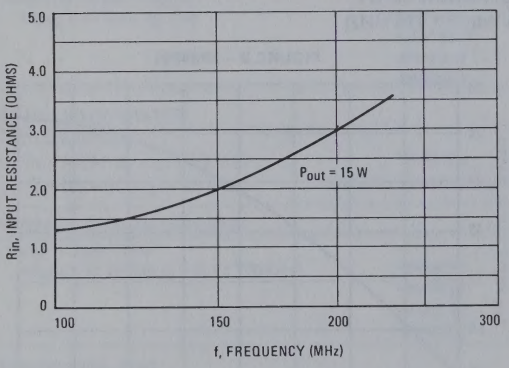


FIGURE 9 – MM4021

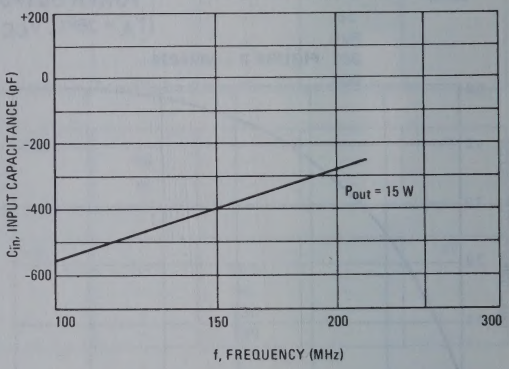


FIGURE 10 – MM4022

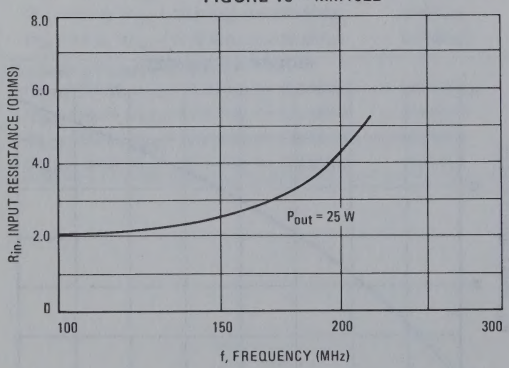
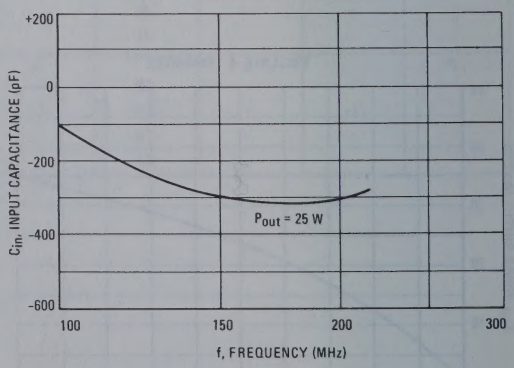


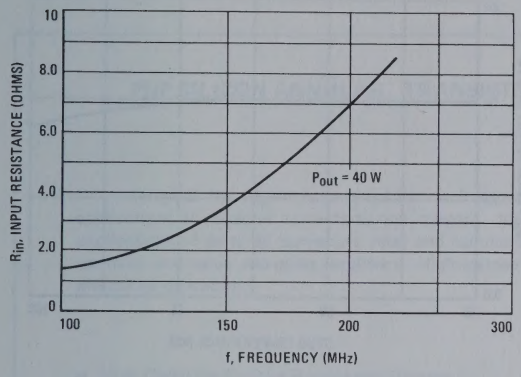
FIGURE 11 – MM4022



CIRCUIT DESIGN DATA

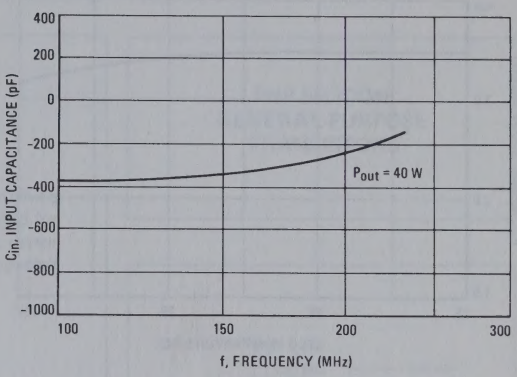
PARALLEL EQUIVALENT INPUT RESISTANCE versus FREQUENCY

FIGURE 12 – MM4023



PARALLEL EQUIVALENT INPUT CAPACITANCE versus FREQUENCY

FIGURE 13 – MM4023



PARALLEL EQUIVALENT OUTPUT CAPACITANCE versus FREQUENCY

(T_A = 25°C, V_{CC} = 12.5 Vdc)

FIGURE 14 – MM4020

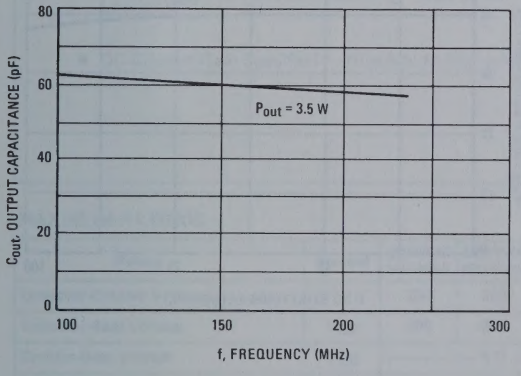


FIGURE 15 – MM4021

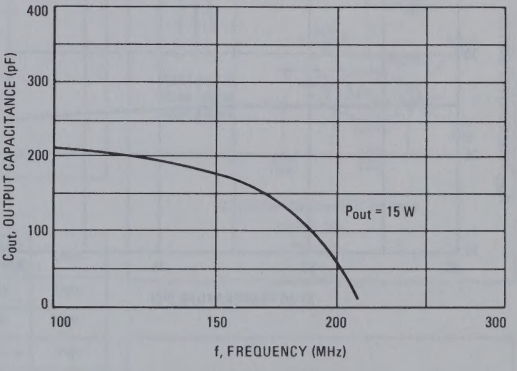


FIGURE 16 – MM4022

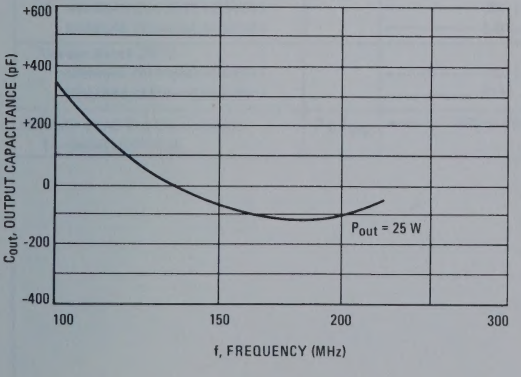
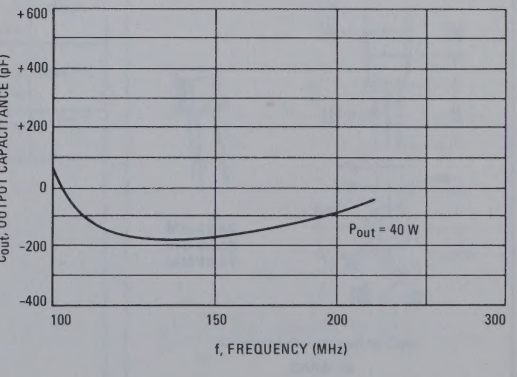


FIGURE 17 – MM4023



TYPICAL POWER SLUMP versus STUD TEMPERATURE

(T_A = 25°C, V_{CC} = 12.5 Vdc, f = 175 MHz)

FIGURE 18 – MM4020

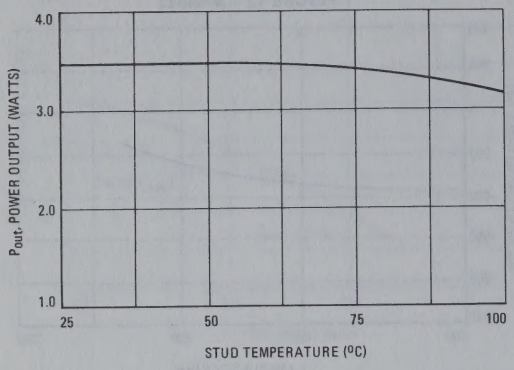


FIGURE 19 – MM4021

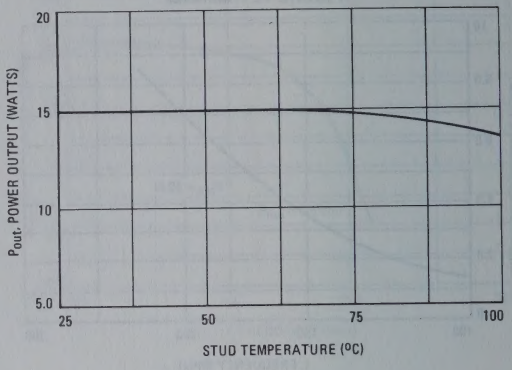


FIGURE 20 – MM4022

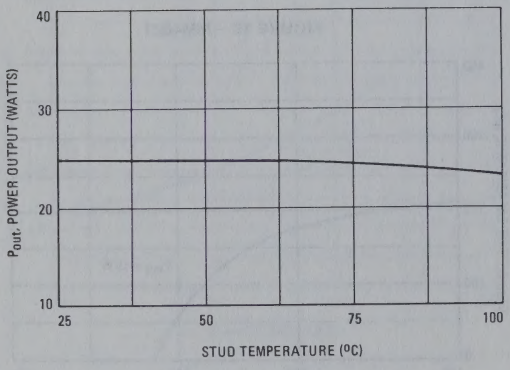
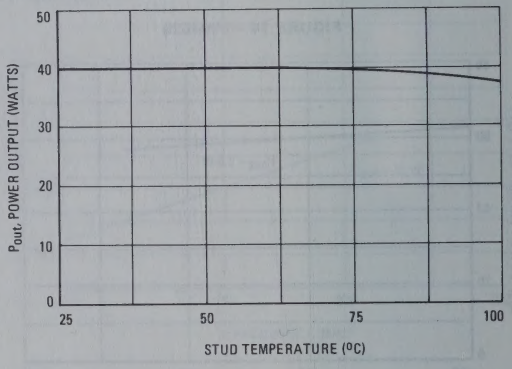


FIGURE 21 – MM4023



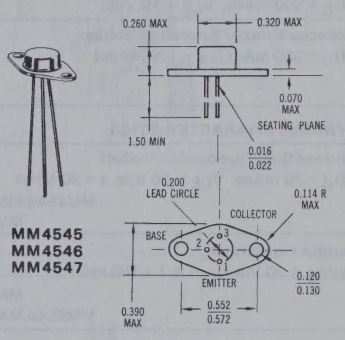
MM4545, MM4546, (SILICON)
MM4547
MM4645, MM4646,
MM4647

PNP SILICON ANNULAR TRANSISTORS

. . . designed for high-voltage amplifier and saturated switching applications at collector currents to one Ampere. Ideally suited for applications of dc-to-dc converters, relay and hammer drivers, motor controls, and servo and pulse amplifiers. High-voltage ratings permit direct-line operation.

- High Collector-Emitter Breakdown Voltage — BV_{CEO} = 200, 300 and 400 Vdc (Min)
- Low Collector-Emitter Saturation Voltage — $V_{CE(sat)}$ = < 1.5 Vdc (Max) @ I_C = 500 mAdc
- DC Current Gain Specified — 10 mAdc to 500 mAdc

PNP SILICON GENERAL-PURPOSE TRANSISTORS

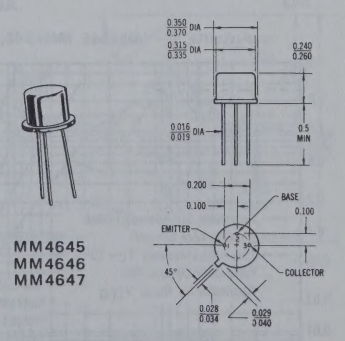


MM4545
MM4546
MM4547

Collector Connected to Case
CASE 39
TO-37

MAXIMUM RATINGS

Rating	Symbol	MM4545 MM4645	MM4546 MM4646	MM4547 MM4647	Unit
Collector-Emitter Voltage	V_{CEO}	200	300	400	Vdc
Collector-Base Voltage	V_{CB}	200	300	400	Vdc
Emitter-Base Voltage	V_{EB}	← 5.0 →			Vdc
Collector Current — Continuous	I_C	← 2.5 →			Adc
Total Device Dissipation @ $T_C = 25^oC$ MM4545,MM4546,MM4547 MM4645,MM4646,MM4647	P_D	← 25 → ← 5.0 →			Watts
Derate above 25^oC MM4545,MM4546,MM4547 MM4645,MM4646,MM4647		← 143 → ← 28.6 →			mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +200 →			^oC



MM4645
MM4646
MM4647

Collector Connected to Case
CASE 79
TO-39

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM4545,MM4645	BV_{CEO}*	200	–	–	Vdc
	MM4546,MM4646		300	–	–	
	MM4547,MM4647		400	–	–	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MM4545,MM4645	BV_{CBO}	200	–	–	Vdc
	MM4546,MM4646		300	–	–	
	MM4547,MM4647		400	–	–	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CE} = 200 Vdc, $V_{BE(off)}$ = 0.5 Vdc)		I_{CEX}	–	–	10	μAdc
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			20	–	–	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*			25	–	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*			20	–	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)	MM4545,MM4645	$V_{CE(sat)}$	–	0.5	1.0	Vdc
	MM4546,MM4646		–	0.6	1.2	
	MM4547,MM4647		–	0.75	1.5	
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product (I_C = 70 mAdc, V_{CE} = 20 Vdc, f = 20 MHz)	MM4545,MM4546,MM4645,MM4646	f_T	40	–	–	MHz
	MM4547,MM4647		30	–	–	
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kHz)	MM4545,MM4645	C_{ob}	–	–	80	pF
	MM4546,MM4547,MM4646,MM4647		–	–	60	
SWITCHING CHARACTERISTICS						
Delay Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc,	t_d	–	30	–	ns
Rise Time	I_{B1} = 50 mAdc)	t_r	–	50	–	ns
Storage Time	(V_{CC} = 100 Vdc, I_C = 500 mAdc,	t_s	–	400	–	ns
Fall Time	I_{B1} = I_{B2} = 50 mAdc)	t_f	–	60	–	ns

*Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2.0%.

ACTIVE-REGION SAFE OPERATING AREA

FIGURE 1 – MM4545, MM4546, MM4547

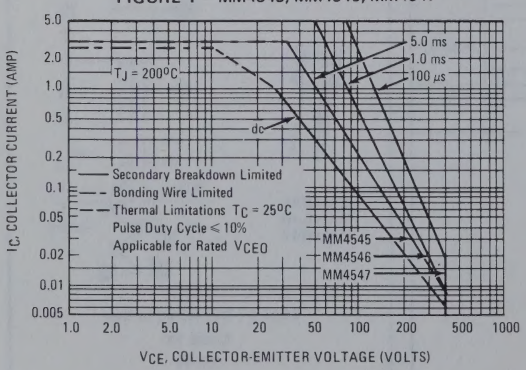
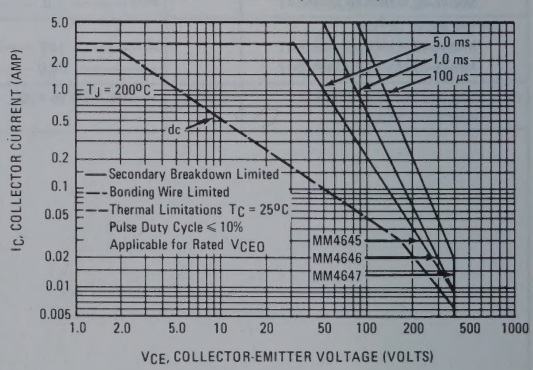


FIGURE 2 – MM4645, MM4646, MM4647



MM8012 (SILICON)

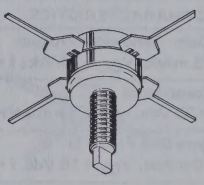
The RF Line

NPN SILICON HIGH-FREQUENCY TRANSISTOR

. . . designed for high-frequency CATV amplifier applications. Suitable for use as output driver or pre-driver stages in VHF and UHF equipment.

- High Current-Gain–Bandwidth Product –
  f_T = 1200 MHz (Min) @ I_C = 75 mAdc
- Low Output Capacitance –
  C_{ob} = 4.0 pF (Max) @ V_{CB} = 30 Vdc
- Low Noise Figure –
  NF = 2.7 dB (Typ) @ I_C = 10 mAdc
- Stripline Package for Low Lead Inductance and Best Heat Dissipation
- Excellent Cross Modulation Performance

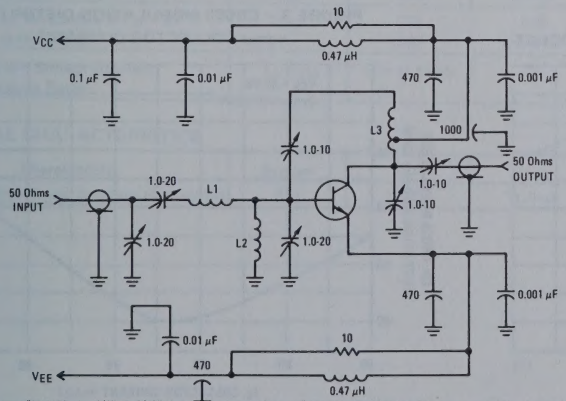
NPN SILICON AMPLIFIER TRANSISTOR



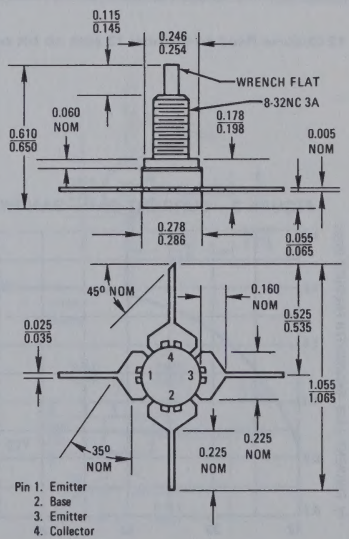
MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current – Continuous	I_C	400	mAdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	5.0 28.6	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 – 200 MHz NOISE FIGURE AND POWER GAIN TEST CIRCUIT



L1 = 3 turns #18 AWG wire, 1/4" ID, 5/16" long
L2 = 1-1/2 turns #18 AWG wire, 1/4" ID, 3/16" long
L3 = 9-3/4 turns #18 AWG wire, 3/16" ID, 1" long, tapped 1-3/4 turn from collector.
All Capacitance in pF unless otherwise noted.



CASE 144D-01

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 30 mAdc, I_B = 0)	$V_{CEO(sus)}$	30	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 1.0 mAdc, I_E = 0)	BV_{CBO}	40	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	–	–	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	–	–	100	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 20 Vdc)	h_{FE}	30	–	–	–
DYNAMIC CHARACTERISTICS					
Current-Gain–Bandwidth Product (I_C = 75 mAdc, V_{CE} = 20 Vdc, f = 200 MHz)	f_T	1200	1500	–	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	2.7	4.0	pF
Noise Figure (See Figure 1) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	NF	–	2.7	–	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (See Figure 1) (I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	G_{pe}	–	11.4	–	dB
Cross Modulation Distortion Ratio(1)	CM				dB
(V_{CE} = 20 Vdc, I_C = 75 mAdc, Output Level = +32 dBmV)		–	-96	–	
(V_{CE} = 20 Vdc, I_C = 75 mAdc, Output Level = +40 dBmV)		–	–	-77	

(1) 12 Channel-Read on Channel 13 with no tilt and synchronous 100% square wave modulation @ 15.75 kHz.

FIGURE 2 – CURRENT-GAIN–BANDWIDTH PRODUCT

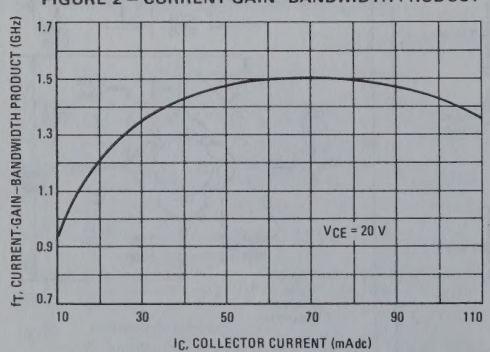
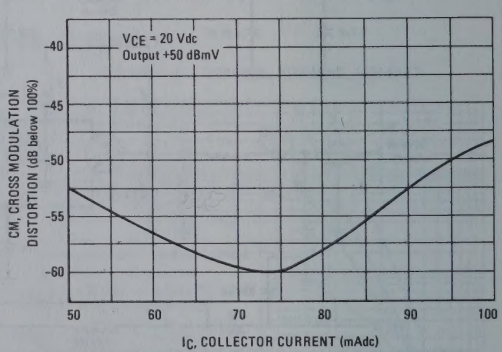


FIGURE 3 – CROSS MODULATION DISTORTION versus COLLECTOR CURRENT



MMT73 (SILICON)

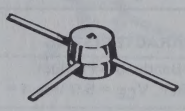
PNP SILICON ANNULAR TRANSISTOR

. . . designed for high-speed, low-current switching applications where high-density packaging is required.

- Ideal for Thick Film Digital Circuit Applications
- One-Piece, Injection-Molded Unibloc Package for High Reliability
- Characteristics Similar to 2N3546

MICRO-MINIATURE

PNP SILICON SWITCHING TRANSISTOR

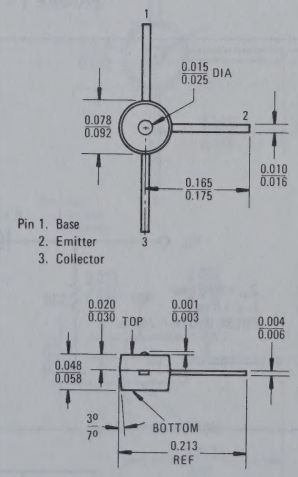


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	8.0	Vdc
Collector-Emitter Voltage	V_{CES}	8.0	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Collector Current — Continuous	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	225 2.05	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.490	^oC/mW



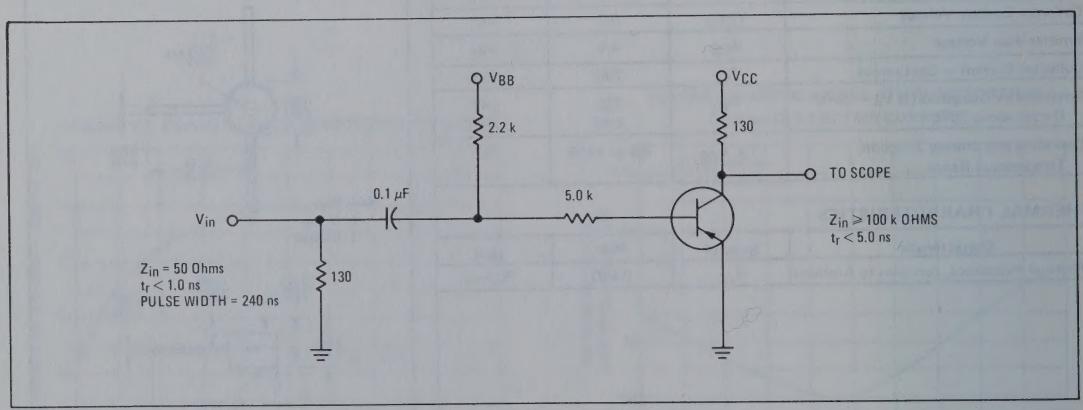
Pin 1. Base
2. Emitter
3. Collector

CASE 28 (1)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	8.0	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	8.0	–	Vdc
Emitter-Base Breakdown Voltage (I_C = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CB} = 3.0 Vdc, I_E = 0)	I_{CBO}	–	100	nAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 50 mAdc, V_{CE} = 1.0 Vdc)	h_{FE}	30 20	– –	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.2	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	5.0	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 1.0 mAdc)	t_{on}	–	30	ns
Turn-Off Time (V_{CC} = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1.0 mAdc)	t_{off}	–	30	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



	V_{in} Vdc	V_{BB} Vdc	V_{CC} Vdc	I_C mA	I_{B1} mA	I_{B2} mA
t_{on}	-5.8	Gnd	-1.5	10	1.0	1.0
t_{off}	+10	-8.0	-1.5	10	1.0	1.0

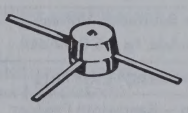
MMT8015 (SILICON)

NPN SILICON RF SMALL–SIGNAL TRANSISTOR

. . . designed for low-noise, high-gain, small-signal microwave amplifiers. Ideal for microstrip circuits where high density packaging is required.

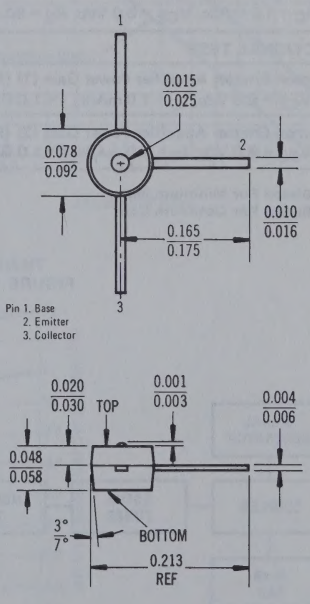
- Unneutralized Power Gain –
  G_{PE} = 12 dB (Typ) @ f = 1.0 GHz
- Low Noise Figure –
  NF = 3.5 dB (Typ) @ f = 1.0 GHz
- Characterized with Scattering Parameters

NPN SILICON MICRO–T
RF SMALL–SIGNAL TRANSISTOR



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	10	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current – Continuous	I_C	15	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.05	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	–55 to +135	°C



CASE 28 (1)

MMT8015 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1.0 mAdc, I_B = 0)	BV_{CEO}	10	–	–	Vdc
Collector-Base Breakdown Voltage (I_C = 0.01 mAdc, I_E = 0)	BV_{CBO}	15	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.01 mAdc, I_C = 0)	BV_{EBO}	3.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 6.0 Vdc, I_E = 0)	I_{CBO}	–	1.0	10	nAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc)	h_{FE}	25	–	300	–
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	–	0.35	–	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 5.0 mAdc)	$V_{BE(sat)}$	–	1.0	–	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 250 MHz)	f_T	1000	2000	–	MHz
Collector-Base Capacitance (V_{CB} = 6.0 Vdc, I_E = 0, f = 100 kHz)	C_{cb}	–	0.50	1.0	pF
Collector-Base Time Constant (I_C = 6.0 mAdc, V_{CE} = 6.0 Vdc, f = 31.8 MHz)	$r_b'C_c$	–	4.0	–	ps
Noise Figure (1) (Figure 1) (I_C = 1.0 mAdc, V_{CE} = 6.0 Vdc, R_S = 50 ohms, f = 1.0 GHz)	NF	–	3.2	4.0	dB
FUNCTIONAL TEST					
Common-Emitter Amplifier Power Gain (1) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc, f = 1.0 GHz)	G_{pe}	6.0	7.5	–	dB
Common-Emitter Amplifier Power Gain (2) (Figure 1) (V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, f = 1.0 GHz)	G_{pe}	10	13	–	dB

(1) Biased For Minimum Noise
(2) Biased For Optimum Gain

FIGURE 1 – POWER GAIN AND NOISE FIGURE TEST CIRCUIT

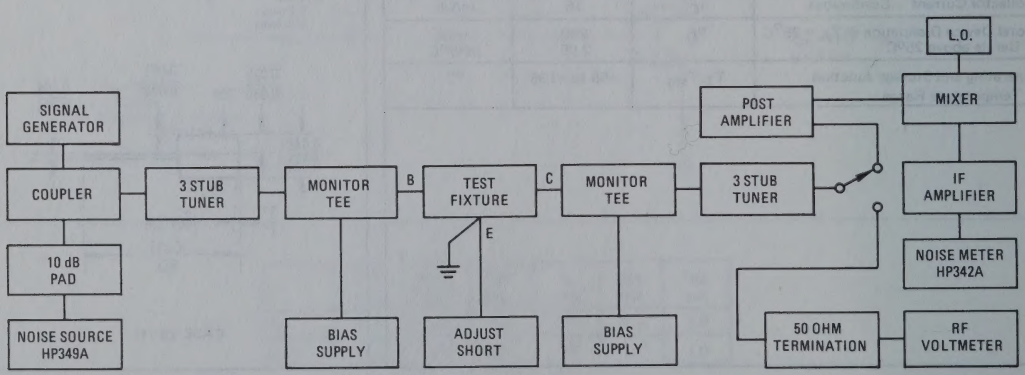


FIGURE 2 – COLLECTOR–BASE CAPACITANCE versus VOLTAGE

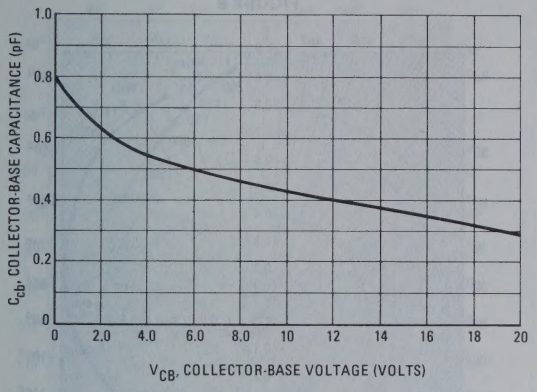


FIGURE 3 – CURRENT–GAIN – BANDWIDTH PRODUCT

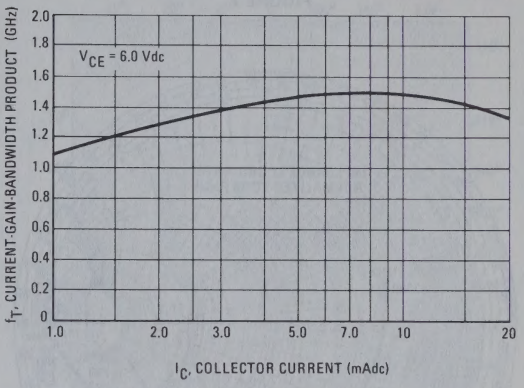


FIGURE 4 – NOISE FIGURE versus FREQUENCY

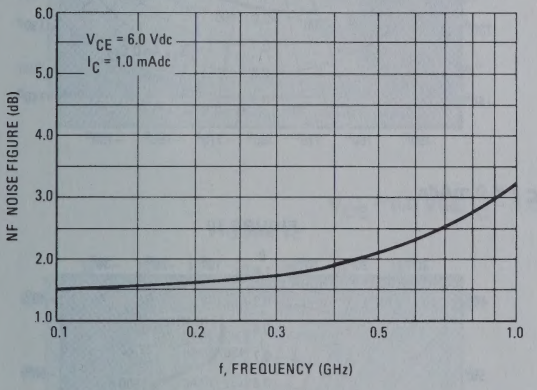


FIGURE 5 – UNNEUTRALIZED POWER GAIN versus FREQUENCY

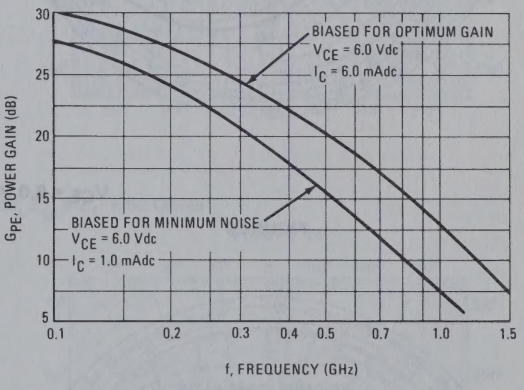
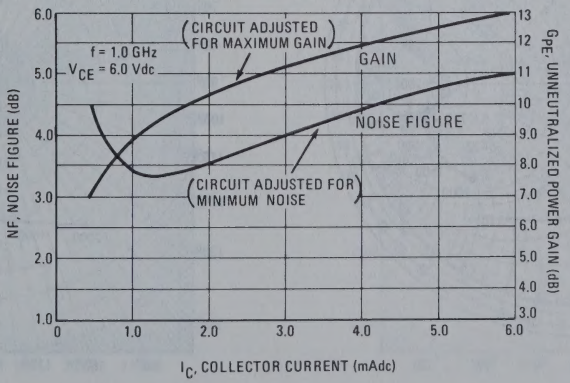


FIGURE 6 – NOISE FIGURE AND GAIN versus CURRENT
(See Test Circuit Figure 1)



S_{11}, S_{22}, INPUT AND OUTPUT REFLECTION COEFFICIENTS

V_{CE} = 6.0 Vdc, I_C = 1.0 mAdc

FIGURE 7

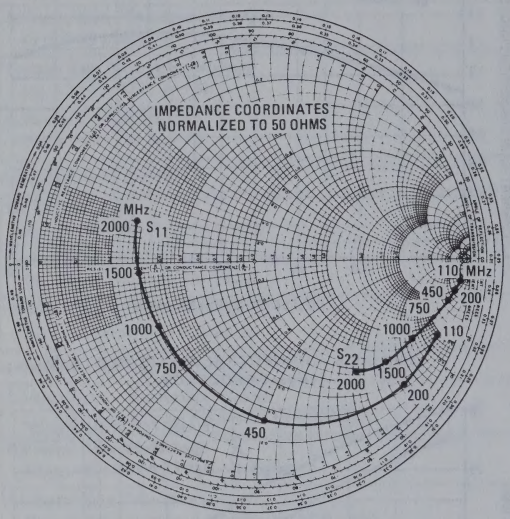
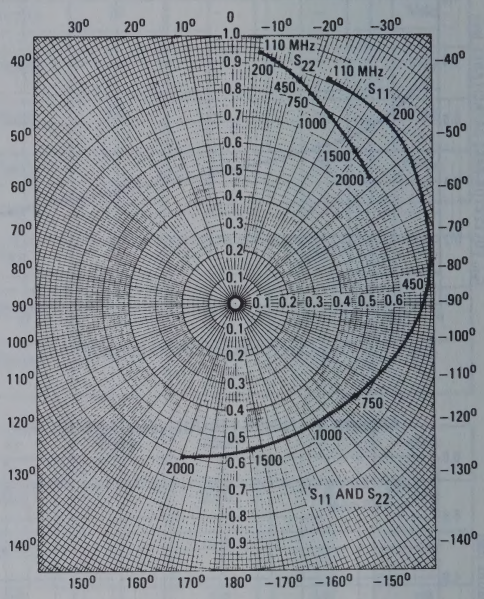


FIGURE 8



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc

FIGURE 9

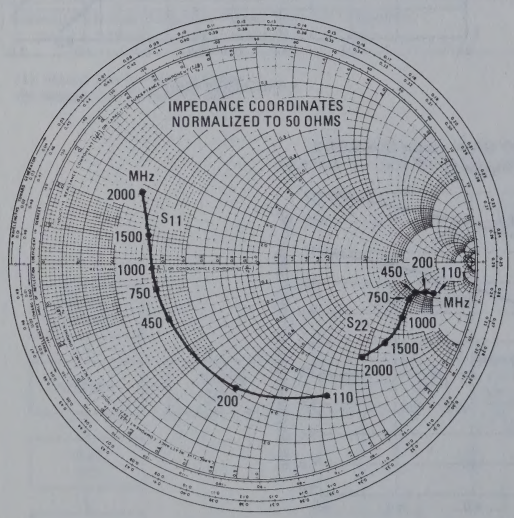
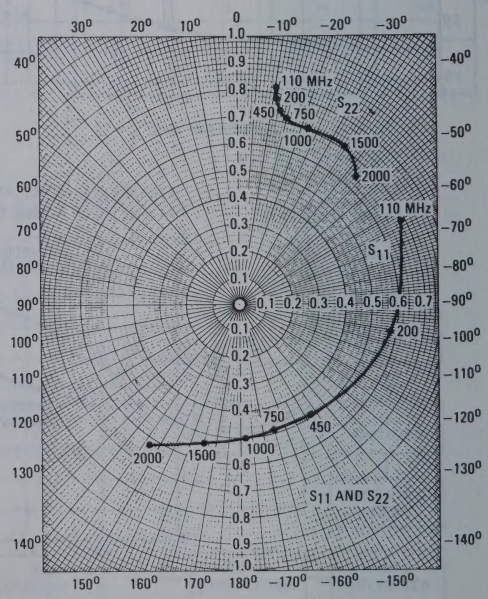


FIGURE 10



S_{12}, REVERSE TRANSMISSION COEFFICIENT

S_{21}, FORWARD TRANSMISSION COEFFICIENT

V_{CC} = 6.0 Vdc, I_C = 1.0 mAdc, Z_G = Z_L = 50 Ohms

FIGURE 11

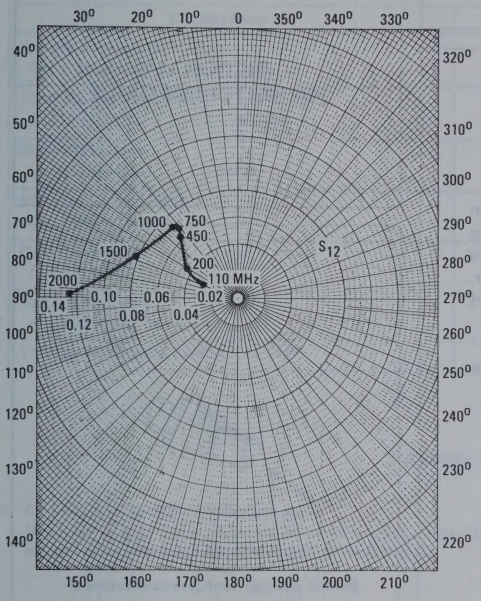
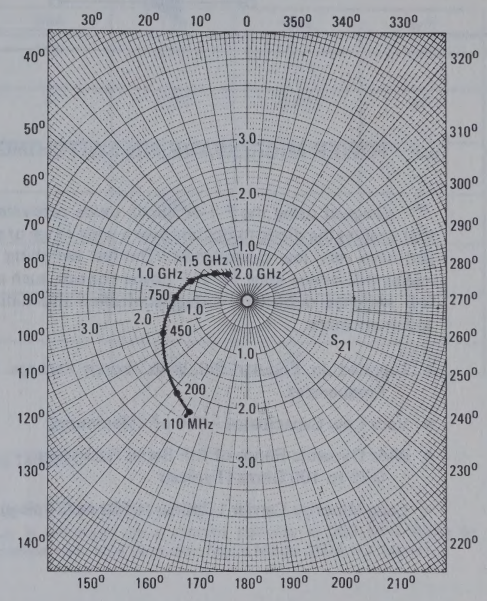


FIGURE 12



V_{CE} = 6.0 Vdc, I_C = 6.0 mAdc, Z_G = Z_L = 50 Ohms

FIGURE 13

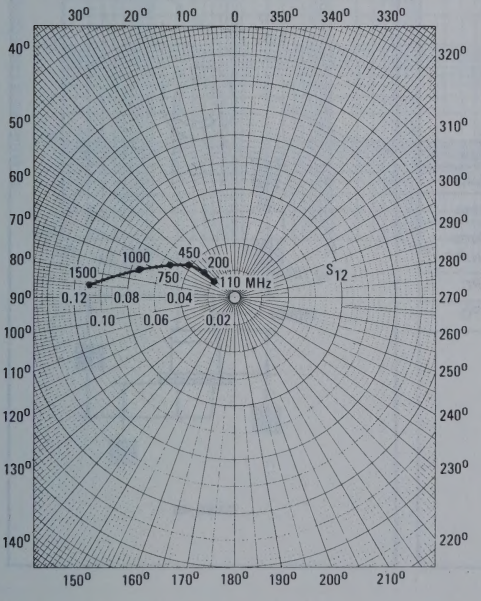
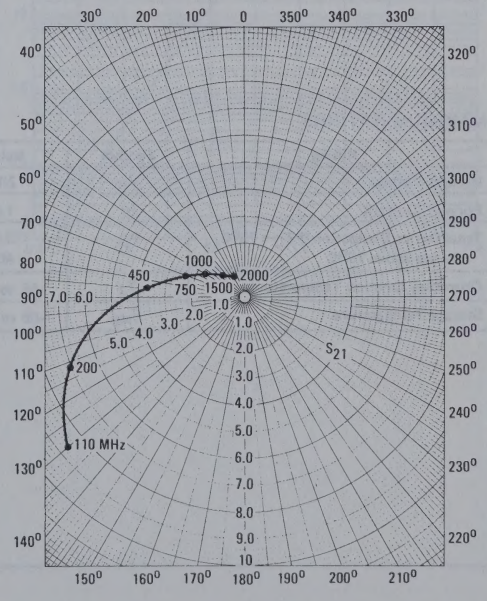
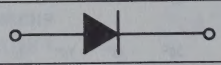


FIGURE 14



MPN3202 (SILICON)

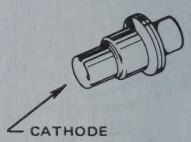


POWER MICROWAVE PIN SWITCHING DIODE

. . . designed using the P-I-N silicon oxide passivated construction that enables the diode to operate over a wide range of series resistance and have very low capacitance. The fast switching time capability makes this device ideal for R-F power control, such as phase shifter, R-F switches, duplexers, voltage-controlled attenuators, modulators and many more.

- Supplied in Popular Pill With Prongs Package for Microwave Frequencies
- Very Low Capacitance – 0.4 pF (Maximum)
- Wide Dynamic Range of R-F Series Resistance – 0.75 to 100 Ohms (Typical)
- Long Minority Carrier Lifetime – 150 ns (Typical)

MICROWAVE PIN SWITCHING DIODE

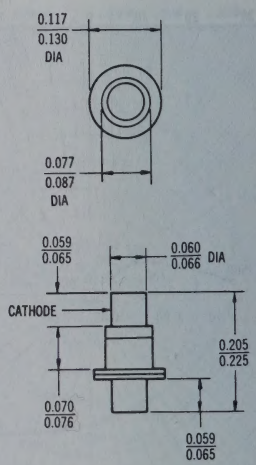


Pill with prongs package

Special package configurations available upon special request.

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	200	Volts
Forward Current	I_F	1.0	Amp
Total Device Dissipation @ $T_C = 75^oC$ Derate above 75^oC	P_D	3.0 40	Watts $mW/^oC$
Operating Junction Temperature	T_J	-55 to +150	^oC
Storage Temperature	T_{stg}	-65 to +175	^oC



CASE 46

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	$V_{(BR)R}$	200	230	–	Volts
Total Device Capacitance (V_R = 50 V, f = 1.0 MHz) (Note 1)	C_T	–	0.33	0.40	pF
Series Resistance (I_F = 100 mAdc, f = 1.0 GHz)	R_S	–	0.75	1.0	Ohm
Minority Carrier Lifetime (I_F = 50 mAdc)	τ	–	150	–	ns
Case Capacitance (f = 1.0 MHz) (Note 1)	C_C	–	0.18	–	pF
Series Inductance (f = 250 MHz) (Note 2)	L_S	–	0.85	–	nH
Thermal Resistance, Junction to Case	θ_{JC}	–	–	25	°C/W

PARAMETER TEST METHODS

1. C_T, and C_C CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge Boonton Electronics Model 75A or equivalent).

2. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

FIGURE 1 – SERIES RESISTANCE

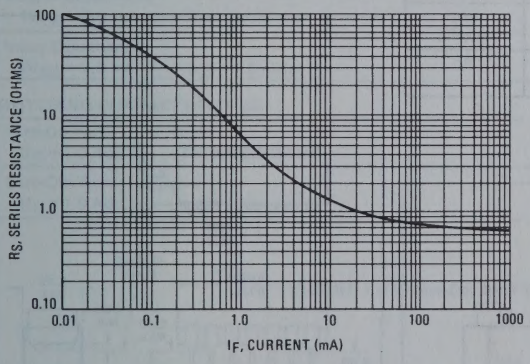
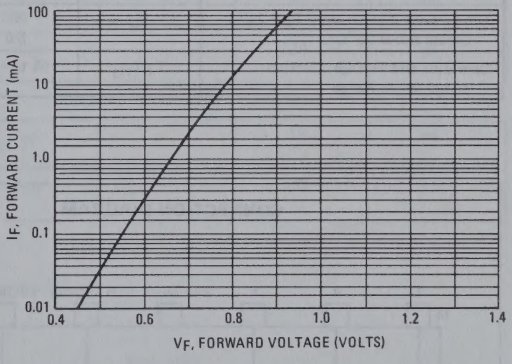


FIGURE 2 – FORWARD VOLTAGE



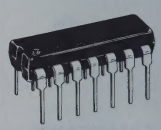
MPQ3303 (SILICON)

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTOR

. . . designed for high-speed, high-current switching and driver applications.

- Low Collector-Emitter Saturation Voltage –
  $V_{CE(sat)}$ = 0.7 Vdc (Max) @ I_C = 1.0 Adc
- High Current-Gain–Bandwidth Product –
  f_T = 400 MHz (Min) @ I_C = 100 mAdc
- Fast Switching Speeds at High Currents –
  t_{on} = 15 ns (Max) @ I_C = 1.0 Adc
  t_{off} = 20 ns (Max) @ I_C = 1.0 Adc

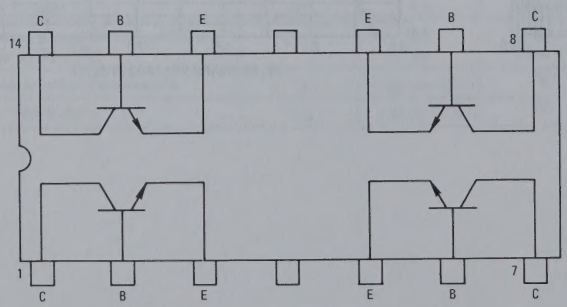
NPN SILICON QUAD CORE DRIVER TRANSISTOR

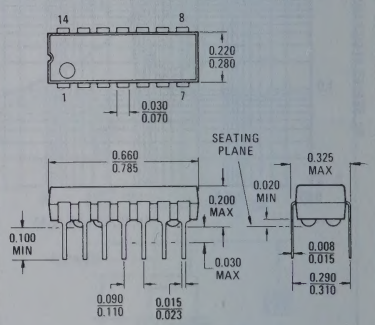


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	600 6.0	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +125	°C

CONNECTION DIAGRAM



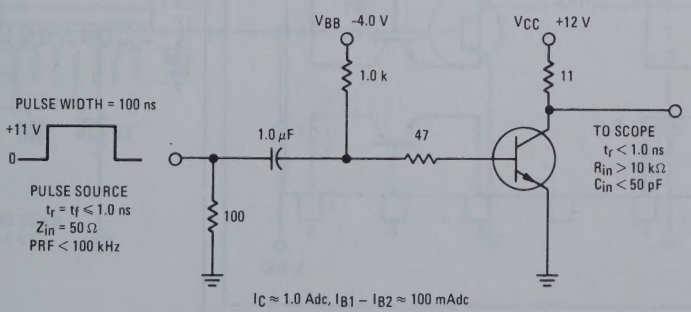


CASE 605-05
TO-116

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	12	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4.0	–	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	–	100	μAdc
ON CHARACTERISTICS				
DC Current Gain (I_C = 300 mAdc, V_{CE} = 0.5 Vdc) (I_C = 1.0 Adc, V_{CE} = 1.0 Vdc)	h_{FE}	 40 30	 200 –	–
Collector-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{CE(sat)}$	 – –	 0.33 0.7	Vdc
Base-Emitter Saturation Voltage (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 1.0 Adc, I_B = 0.1 Adc)	$V_{BE(sat)}$	 – –	 1.1 1.4	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5.0 Vdc, f = 100 MHz)	f_T	400	–	MHz
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 1.0 MHz)	C_{ob}	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1.0 MHz)	C_{ib}	–	30	pF
SWITCHING CHARACTERISTICS				
Turn-On Time (Figure 1) (I_C = 1.0 Adc, I_{B1} = 100 mAdc)	t_{on}	–	15	ns
Turn-Off Time (Figure 1) (I_C = 1.0 Adc, I_{B1} = I_{B2} = 100 mAdc)	t_{off}	–	20	ns

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT



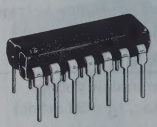
MPQ3725 (SILICON)

NPN SILICON ANNULAR QUAD CORE DRIVER TRANSISTOR

. . . designed for medium-current, high-speed switching and driver applications.

- High Collector-Emitter Breakdown Voltage —
  BV_{CEO} = 40 Vdc (Min) @ I_C = 10 mAdc
- Fast Switching Times —
  t_{on} = 20 ns (Typ) @ I_C = 500 mAdc
  t_{off} = 50 ns (Typ) @ I_C = 500 mAdc

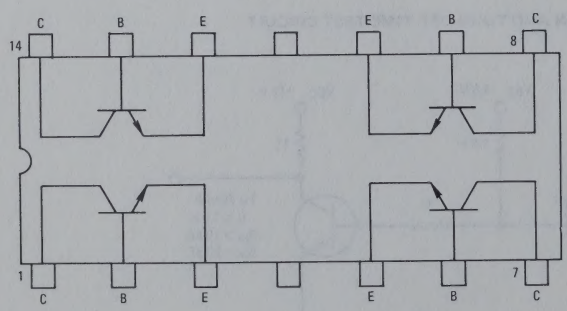
NPN SILICON QUAD CORE DRIVER TRANSISTOR

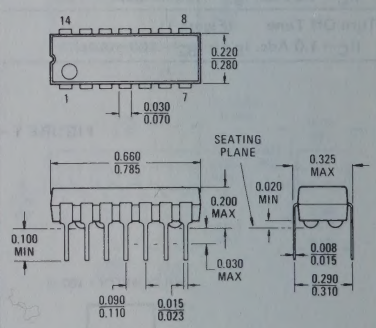


MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	600 6.0	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +125	^oC

CONNECTION DIAGRAM



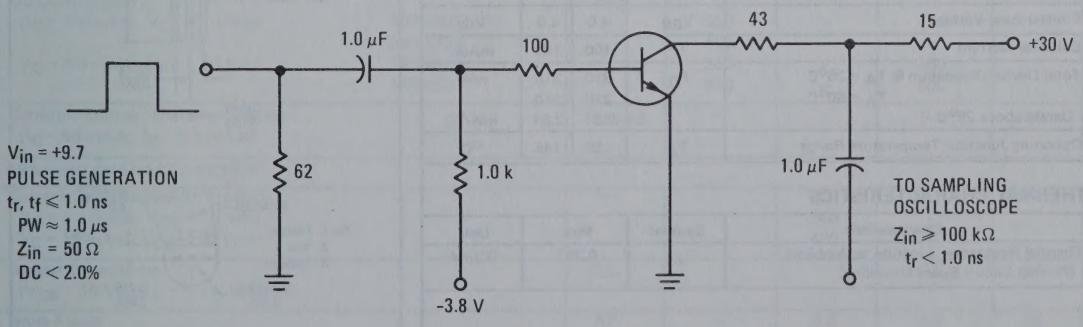


CASE 605-05
TO-116

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	BV_{CEO}	40	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	60	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5.0	–	–	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0)	I_{CBO}	–	–	0.5	μAdc
ON CHARACTERISTICS					
DC Current Gain	h_{FE}				–
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)		35	–	200	
(I_C = 500 mAdc, V_{CE} = 2.0 Vdc)		25	–	–	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{CE(sat)}$	–	–	0.45	Vdc
Base-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	$V_{BE(sat)}$	0.8	–	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	250	–	–	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	–	–	10	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)	C_{ib}	–	–	80	pF
SWITCHING CHARACTERISTICS					
Turn-On Time (Figure 1) (I_C = 500 mAdc, I_{B1} = 50 mAdc)	t_{on}	–	20	35	ns
Turn-Off Time (Figure 1) (I_C = 500 mAdc, I_{B1} = I_{B2} = 50 mAdc)	t_{off}	–	50	60	ns

FIGURE 1 – TURN-ON AND TURN-OFF SWITCHING TIMES TEST CIRCUIT



MPS6520, MPS6521 NPN (SILICON)
MPS6522, MPS6523 PNP

SILICON ANNULAR TRANSISTORS

. . . designed for general-purpose amplifier applications and for complementary circuitry.

- High DC Current Gain –
  h_{FE} = 150 (Min) @ I_C = 100 μAdc – MPS6521, MPS6523
- Low Noise Figure –
  NF = 1.8 dB (Typ) @ I_C = 10 μAdc
- Low Output Capacitance –
  C_{ob} = 3.5 pF (Max) @ V_{CB} = 10 Vdc

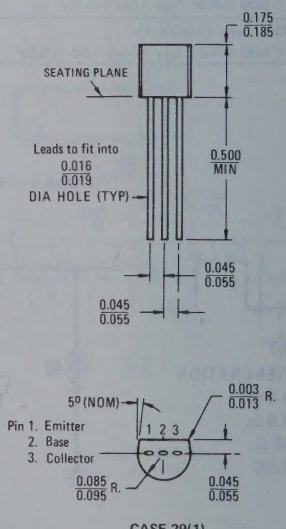
SILICON COMPLEMENTARY AMPLIFIER TRANSISTORS

MAXIMUM RATING

Rating	Symbol	NPN	PNP	Unit
Collector-Emitter Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CEO}	 25	 25	Vdc
Collector-Base Voltage MPS6520, MPS6521 MPS6522, MPS6523	V_{CB}	 40	 25	Vdc
Emitter-Base Voltage	V_{EB}	4.0	4.0	Vdc
Collector Current	I_C	100	100	mAdc
Total Device Dissipation @ T_A = 25°C T_A = 60°C Derate above 25°C	P_D	310 210 2.81	310 210 2.81	mW mW/°C
Operating Junction Temperature Range	T_J	135	135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient (Printed Circuit Board Mounting)	θ_{JA}	0.357	°C/mW



CASE 29(1)
TO-92

MPS6520, MPS6521 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			–	–	0.05	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6520		100	–	–	
	MPS6521		150	–	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6520		200	–	400	
	MPS6521		300	–	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			–	390	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			–	480	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	–	1.8	3.0	dB

MPS6522, MPS6523 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)		BV_{CEO}	25	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.0	–	–	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 20 Vdc, I_E = 0)			–	–	0.05	
(V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)			–	–	1.0	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				–
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6522		100	–	–	
	MPS6523		150	–	–	
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)	MPS6522		200	–	400	
	MPS6523		300	–	600	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5.0 mAdc)		$V_{CE(sat)}$	–	–	0.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain–Bandwidth Product		f_T				MHz
(I_C = 2.0 mAdc, V_{CE} = 10 Vdc)			–	340	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)			–	420	--	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	–	–	3.5	pF
Noise Figure (I_C = 10 μAdc, V_{CE} = 5.0 Vdc, R_S = 10 k ohms, Power Bandwidth = 15.7 kHz, 3.0 dB points @ 10 Hz and 10 kHz)		NF	–	1.8	3.0	dB

ELECTRICAL CHARACTERISTICS (V_{CE} = 10 V, T_A = 25°C unless otherwise noted)

FIGURE 2 – NORMALIZED DC CURRENT GAIN

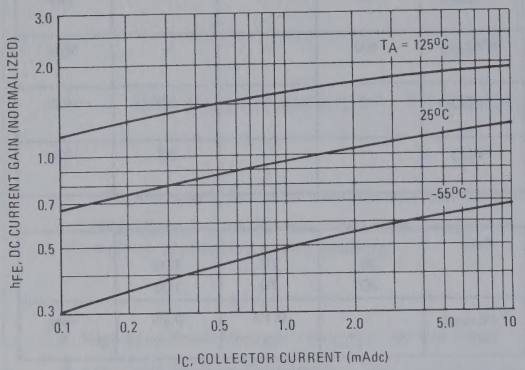


FIGURE 3 – "ON" VOLTAGES

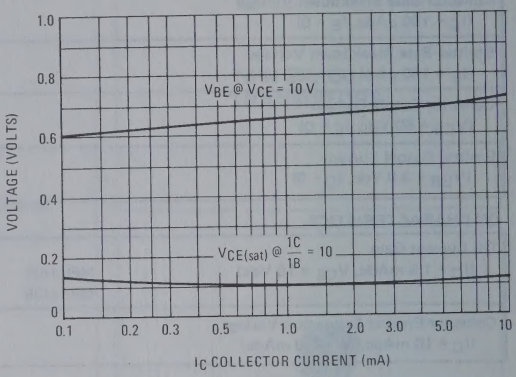


FIGURE 4 – CURRENT-GAIN–BANDWIDTH PRODUCT

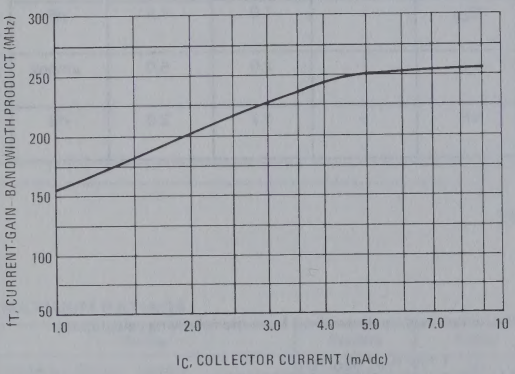


FIGURE 5 – COLLECTOR-BASE CAPACITANCE versus VOLTAGE

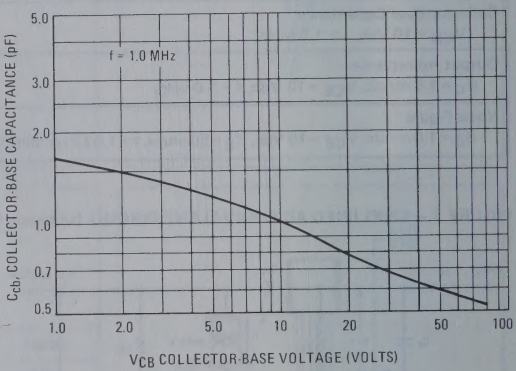


FIGURE 6 – OUTPUT ADMITTANCE

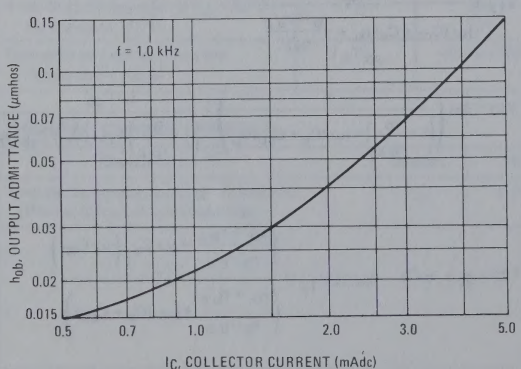
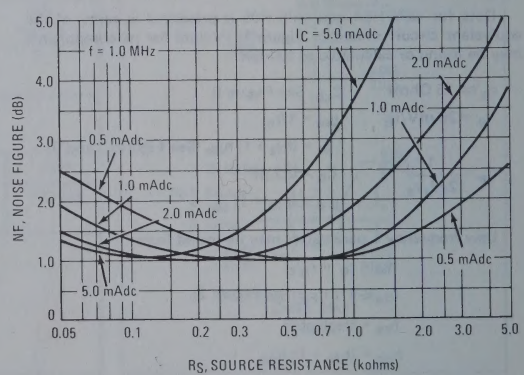
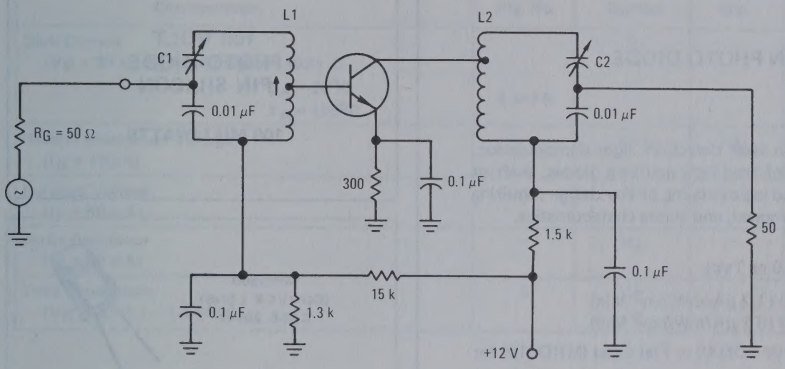


FIGURE 7 – NOISE FIGURE



AM RADIO DESIGN INFORMATION

FIGURE 8 – 1.0 MHz AMPLIFIER TEST CIRCUIT



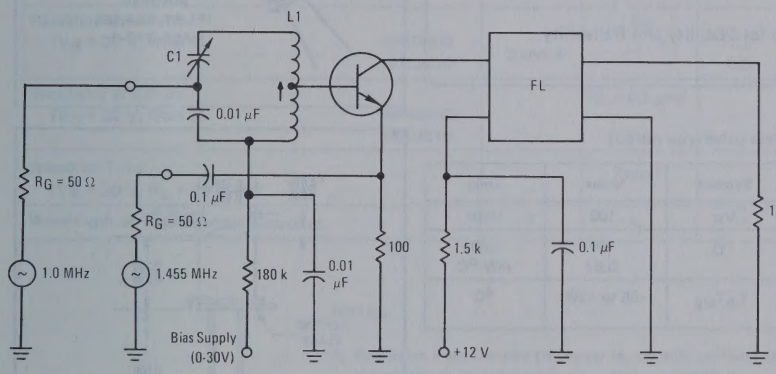
L1 90 turns of 7 x 41 Litz wire on 1/4" form, tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, $Q_u \approx 130$ Loaded Q, $Q_L \approx 60$

L2 90 turns of 7 x 41 Litz wire on 1/4" form, tapped 21 turns from high end. Turns ratio of coil ≈ 1.3, unloaded Q, $Q_u \approx 130$, Loaded Q, $Q_L \approx 60$

C1 25-280 pF Variable

C2 100-400 pF Variable

FIGURE 9 – 1.0 MHz MIXER TEST CIRCUIT



L1 90 turns of 7 x 41 Litz wire on 1/4" form; tapped 4 turns from ground end. Turns ratio of coil ≈ 22, unloaded Q, $Q_u \approx 130$, Loaded Q, $Q_L \approx 60$.

C1 25-280 pF Variable

FL 455 kHz Filter

FIGURE 10 – AMPLIFIER POWER GAIN

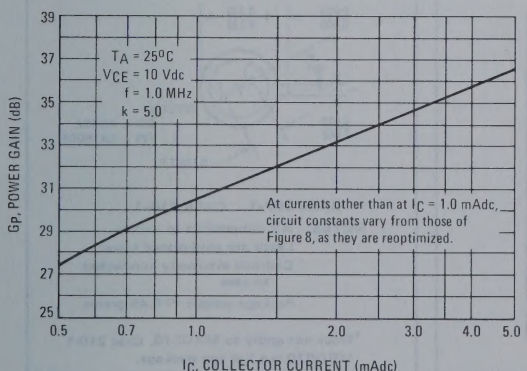
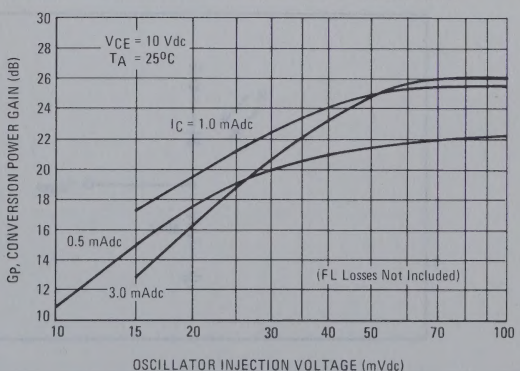

T_A = 25°C
V_{CE} = 10 Vdc
f = 1.0 MHz
k = 5.0
At currents other than at I_C = 1.0 mAdc, circuit constants vary from those of Figure 8, as they are reoptimized.
G_p, POWER GAIN (dB)
I_C, COLLECTOR CURRENT (mAdc)

FIGURE 11 – CONVERSION POWER GAIN



MRD500 (SILICON)
MRD510

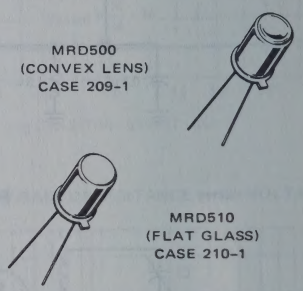
PIN SILICON PHOTO DIODE

. . . designed for application in laser detection, light demodulation, detection of visible and near infrared light-emitting diodes, shaft or position encoders, switching and logic circuits, or any design requiring radiation sensitivity, ultra high-speed, and stable characteristics.

- Ultra Fast Response – (<1.0 ns Typ)
- High Sensitivity – MRD500 (1.2 μA/mW/cm^2 Min)
  MRD510 (0.3 μA/mW/cm^2 Min)
- Available With Convex Lens (MRD500) or Flat Glass (MRD510) for Design Flexibility
- Popular TO-18 Type Package for Easy Handling and Mounting
- Sensitive Throughout Visible and Near Infrared Spectral Range for Wide Application
- Annular Passivated Structure for Stability and Reliability

100 VOLT
PHOTO DIODE
PIN SILICON

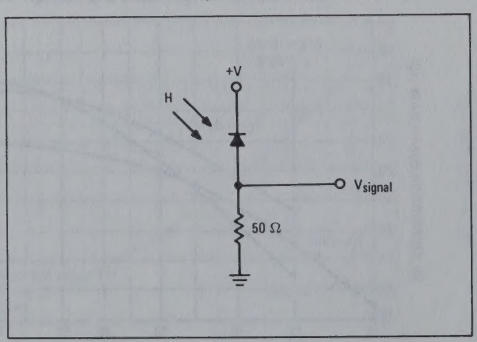
100 MILLIWATTS

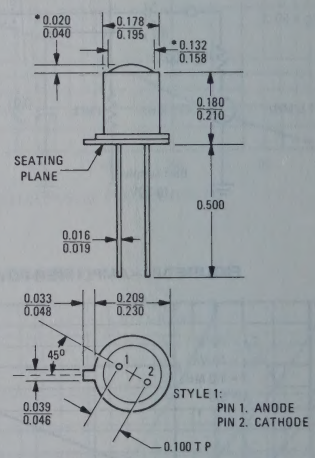


MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	100	Volts
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	100 0.57	mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 – TYPICAL OPERATING CIRCUIT





CASE 209-1 CASE 210-1

NOTES: All dimensions in inches
Leads are gold-plated kovar
Cathode internally connected to case
Package weight ≈ 0.45 grams

*Does not apply to MRD510, Case 210-1
MRD510 is a flat top package.

STATIC ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Dark Current (V_R = 20 V, R_L = 1.0 megohm; Note 2)		I_D				nA
T_A = 25°C	4 and 5		–	–	2.0	
T_A = 100°C			–	14	–	
Reverse Breakdown Voltage (I_R = 10 μA)	–	BV_R	100	200	–	Volts
Forward Voltage (I_F = 50 mA)	–	V_F	–	–	1.1	Volts
Series Resistance (I_F = 50 mA)	–	R_s	–	–	10	ohms
Total Capacitance (V_R = 20 V; f = 1.0 MHz)	6	C_T	–	–	4	pF

OPTICAL CHARACTERISTICS (T_A = 25°C)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Radiation Sensitivity (V_R = 20 V, Note 1)			S_R				μA/mW/cm^2
	MRD500	2 and 3		1.2	1.8	–	
	MRD510			0.3	0.42	–	
Sensitivity at 0.8 μm			$S(\lambda = 0.8\ \mu m)$				μA/mW/cm^2
(V_R = 20 V, Note 3)	MRD500	–		–	6.6	–	
	MRD510	–			1.5	–	
Response Time		–	$t_{(resp)}$		1.0		ns
(V_R = 20 V, R_L = 50 ohms)		–					
Wavelength of Peak Spectral Response		7	λ_s	–	0.8	–	μm

NOTES:

1. Radiation Flux Density (H) equal to 5.0 mW/cm^2 emitted from a tungsten source at a color temperature of 2870 K.
2. Measured under dark conditions. ($H \approx 0$).
3. Radiation Flux Density (H) equal to 0.5 mW/cm^2 at 0.8 μm.

TYPICAL ELECTRICAL CHARACTERISTICS

FIGURE 2 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD500

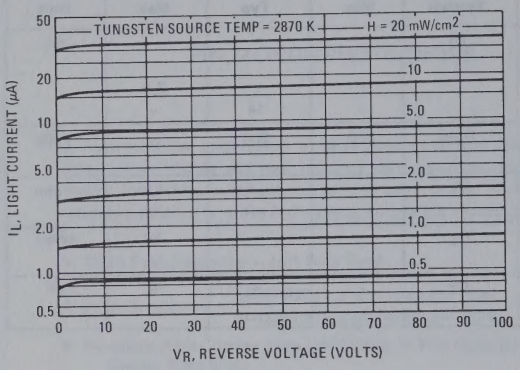


FIGURE 3 – IRRADIATED VOLTAGE – CURRENT CHARACTERISTIC FOR MRD 510

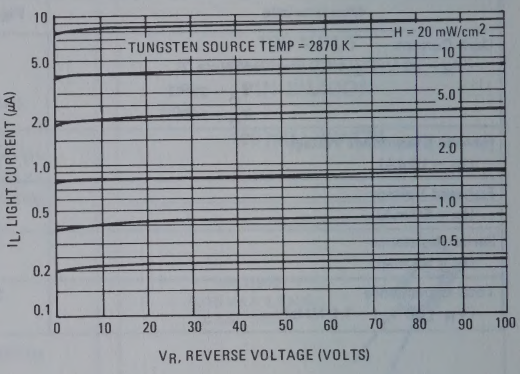


FIGURE 4 – DARK CURRENT versus TEMPERATURE

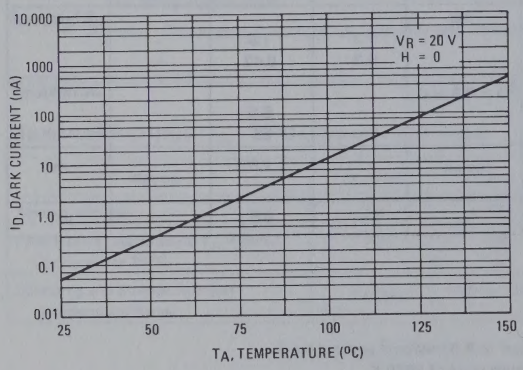


FIGURE 5 – DARK CURRENT versus REVERSE VOLTAGE

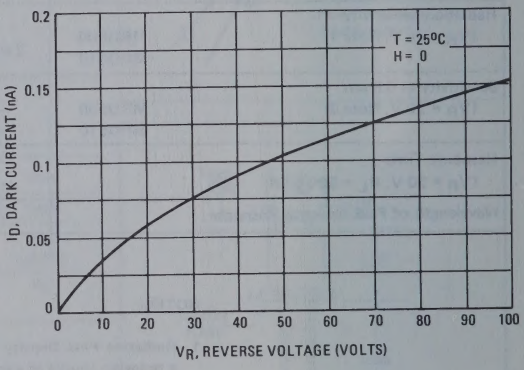


FIGURE 6 – CAPACITANCE versus VOLTAGE

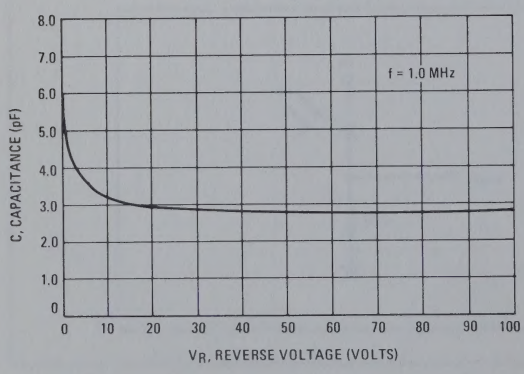
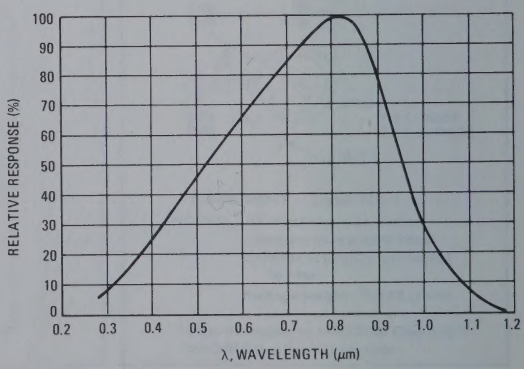


FIGURE 7 – RELATIVE SPECTRAL RESPONSE



MRD500 AND MRD510
OPTOELECTRONIC DEFINITIONS, CHARACTERISTICS, AND RATINGS

BV_R Reverse Breakdown Voltage – The minimum dc reverse breakdown voltage at stated diode current and ambient temperature.

C_T Total Capacitance

H Radiation Flux Density (Irradiance) [mW/cm^2] – The total incident radiation energy measured in power per unit area.

I_D Dark Current – The maximum reverse leakage current through the device measured under dark conditions, ($H \approx 0$), with a stated reverse voltage, load resistance, and ambient temperature.

P_D Power Dissipation

R_S Series Resistance – The maximum dynamic series resistance measured at stated forward current and ambient temperature.

S_R Radiation Sensitivity ($\mu A/mW/cm^2$) – The ratio of photo-induced current to the incident radiant energy measured at the plane of the lens of the photo device under stated conditions of radiation flux density (H), reverse voltage, load resistance, and ambient temperature.

T_A Ambient Temperature

T_J Junction Temperature

T_{stg} Storage Temperature

V_F Forward Voltage – The maximum forward voltage drop across the diode at stated diode current and ambient temperature.

V_R Reverse Voltage – The maximum allowable value of dc reverse voltage which can be applied to the device at the rated temperature.

$\lambda_s(\mu m)$ Wavelength of peak spectral response in micro – meters.

OPTO DEVICES

AN-440 – THEORY AND CHARACTERISTICS OF PHOTO TRANSISTORS

A brief history of the photoelectric effect is discussed, followed by a comprehensive analysis of the effect in bulk semiconductors, pn junctions and phototransistors. A model is presented for the phototransistor. Static and transient data for the MRD300 provide typical phototransistor characteristics. Appendices provide a discussion of the relationship of irradiation and illumination and define terms specifically related to phototransistors.

MV1401, MV1403 (SILICON)
MV1404, MV1405

VVC

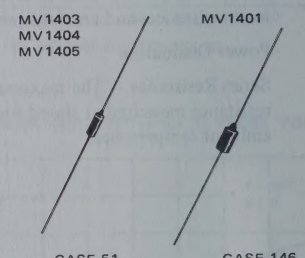
SILICON HYPER-ABRUPT JUNCTION TUNING DIODES

. . . designed with a capacitance change of greater than TEN TIMES for a bias change ranging from 2 to 10 volts. Provides tuning over broad frequency ranges, tuning AM radio broadcast band, general AFC and tuning applications in lower RF frequencies.

- High Q with Guaranteed Minimum Values
- Broad Capacitance Selection from 120–550 pF (Nominal Values)
- Available in Two Standard Glass Packages

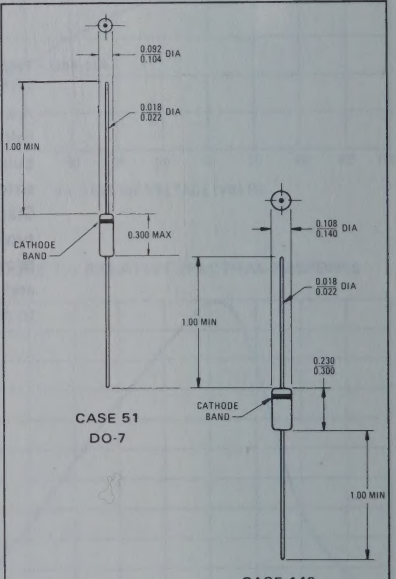
HIGH TUNING RATIO VOLTAGE – VARIABLE CAPACITANCE DIODES

120-550 pF
12 VOLTS



MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Reverse Voltage	V_R	12	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic—All Types	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage (I_R = 10 μAdc)	BV_R	12	—	—	Vdc
Reverse Voltage Leakage Current (V_R = 10 Vdc, T_A = 25°C)	I_R	—	—	0.10	μAdc
Series Inductance (f = 250 MHz, Lead Length ≈ 1/16")	L_S	—	5.0	—	nH
Case Capacitance (f = 1.0 MHz, Lead Length ≈ 1/16")	C_C	—	0.25	—	pF

	C_T, Diode Capacitance						Q, Figure of Merit	TR, Tuning Ratio	
	V_R = 1.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz pF			V_R = 2.0 Vdc, f = 1.0 MHz	C_1/C_{10} f = 1.0 MHz	C_2/C_{10} f = 1.0 MHz
Device	Min	Nom	Max	Min	Nom	Max	Min	Min	Min
MV1401	468	550	633	—	—	—	200	14	—
MV1403	—	—	—	140	175	210	200	—	10
MV1404	—	—	—	96	120	144	200	—	10
MV1405	—	—	—	200	250	300	200	—	10

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE

L_S is measured on a shorted package at 250 MHz using an impedance bridge (Boonton Radio Model 250A RX Meter).

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1.0 MHz using a capacitance bridge (Boonton Electronics Model 75A or equivalent).

4. TR, TUNING RATIO

TR is the ratio of C_T measured at 2.0 Vdc (1.0 Vdc for MV1401) divided by C_T measured at 10 Vdc.

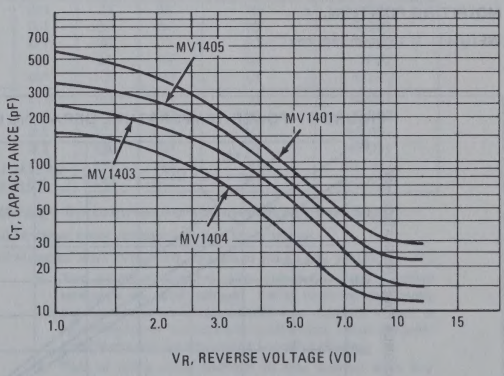
5. Q, FIGURE OF MERIT

Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equation:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8). Use Lead Length ≈1/16".

FIGURE 1 – DIODE CAPACITANCE versus REVERSE VOLTAGE



MZ92-2.4, A, B (SILICON)
thru
MZ92-200, A, B

500 mW UNIBLOC SILICON OXIDE PASSIVATED ZENER REGULATOR DIODES

Highly reliable silicon regulators utilizing an oxide-passivated junction for long-term voltage stability. Supplied in the popular TO-92 plastic package for the high volume requirements of the consumer industry.

- In-Line Leads for Easy Insertion
- Lower Cost in High Volume
- Electrically Similar to Our Popular Surmetic 20 Series "1N5221 – 1N5281"
- Wide Voltage Selection – 2.4-200 V

UNIBLOC ZENER REGULATOR DIODES

500 MILLIWATTS
2.4 thru 200 VOLTS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_L = 55^oC$ Lead Length = 1/4"	P_D	500	mW
Derate above 55^oC (Figure 1)		5.26	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	^oC

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded, thermosetting plastic

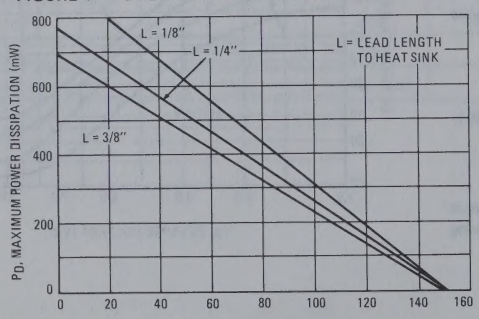
FINISH: All external surfaces are corrosion resistant. Leads are readily solderable and weldable

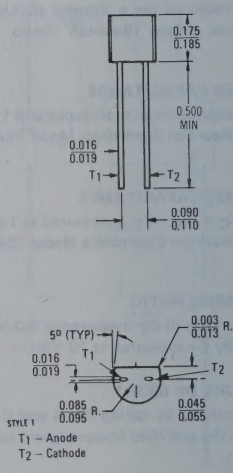
POLARITY: Cathode indicated by color dot. When operated in zener mode, cathode will be positive with respect to anode

MOUNTING POSITION: Any

WEIGHT: 0.18 gram (approx)

FIGURE 1 – POWER-TEMPERATURE DERATING CURVE





CASE 182 (1)

MZ92-2.4,A,B thru MZ92-200,A,B (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted. Based on dc measurements at thermal equilibrium; lead length = 1/4"; thermal resistance of heat sink ≈ 30°C/W), V_F = 1.5 Max @ I_F = 200 mA for all types.)

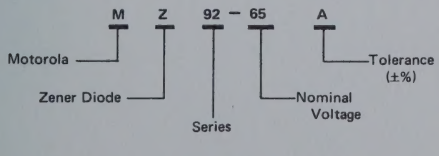
Motorola Type Number (Note 1)	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance A & B Suffix Only		Max Reverse Leakage Current A & B Suffix Only			Non-Suffix	Typical Zener Voltage Temp. Coeff. θ_{VZ} (%/°C) (Note 3)
			Z_{ZT} @ I_{ZT} Ohms	Z_{ZK} @ I_{ZK} = 0.25 mA Ohms	I_R μA	@ V_R Volts A	@ V_R Volts B	I_R @ V_R Used For Suffix A μA	
MZ92-2.4	2.4	20	50	2100	100	0.95	1.0	200	−1.03
MZ92-2.5	2.5	20	50	2100	100	0.95	1.0	200	−1.03
MZ92-2.7	2.7	20	50	2200	75	0.95	1.0	150	−1.01
MZ92-2.8	2.8	20	50	2200	75	0.95	1.0	150	−1.00
MZ92-3.0	3.0	20	50	2300	50	0.95	1.0	100	−0.09
MZ92-3.3	3.3	20	50	2500	25	0.95	1.0	100	−0.068
MZ92-3.6	3.6	20	48	2700	15	0.95	1.0	100	−0.051
MZ92-3.9	3.9	20	40	2800	10	0.95	1.0	75	−0.034
MZ92-4.3	4.3	20	25	2900	5.0	0.95	1.0	50	−0.010
MZ92-4.7	4.7	20	19	2600	5.0	1.9	2.0	50	+0.012
MZ92-5.1	5.1	20	17	2400	5.0	1.9	2.0	50	+0.025
MZ92-5.6	5.6	20	15	2100	5.0	2.9	3.0	50	+0.035
MZ92-6.0	6.0	20	13	1900	5.0	3.3	3.5	50	+0.041
MZ92-6.2	6.2	20	14	1500	5.0	3.8	4.0	50	+0.043
MZ92-6.8	6.8	20	17	780	3.0	4.8	5.0	30	+0.050
MZ92-7.5	7.5	20	23	700	3.0	5.7	6.0	30	+0.055
MZ92-8.2	8.2	20	34	700	3.0	6.2	6.5	30	+0.059
MZ92-8.7	8.7	20	44	700	3.0	6.2	6.5	30	+0.061
MZ92-9.1	9.1	20	50	700	3.0	6.7	7.0	30	+0.062
MZ92-10	10	20	62	700	3.0	7.6	8.0	30	+0.066
MZ92-11	11	20	68	700	2.0	8.0	8.4	30	+0.068
MZ92-12	12	20	70	700	1.0	8.7	9.1	10	+0.070
MZ92-13	13	9.5	70	700	0.5	9.4	9.9	10	+0.072
MZ92-14	14	9.0	70	700	0.1	9.5	10	10	+0.074
MZ92-15	15	8.5	34	700	0.1	10.5	11	10	+0.076
MZ92-16	16	7.8	38	700	0.1	11.4	12	10	+0.077
MZ92-17	17	7.4	42	700	0.1	12.4	13	10	+0.078
MZ92-18	18	7.0	48	700	0.1	13.3	14	10	+0.079
MZ92-19	19	6.6	52	700	0.1	13.3	14	10	+0.080
MZ92-20	20	6.2	57	700	0.1	14.3	15	10	+0.080
MZ92-22	22	5.6	68	700	0.1	16.2	17	10	+0.082
MZ92-24	24	5.2	78	700	0.1	17.1	18	10	+0.083
MZ92-25	25	5.0	85	700	0.1	18.1	19	10	+0.083
MZ92-27	27	4.6	98	700	0.1	20	21	10	+0.084
MZ92-28	28	4.5	105	700	0.1	20	21	10	+0.084
MZ92-30	30	4.2	117	700	0.1	22	23	10	+0.085
MZ92-33	33	3.8	140	700	0.1	24	25	10	+0.086
MZ92-36	36	3.4	160	700	0.1	26	27	10	+0.087
MZ92-39	39	3.2	190	800	0.1	29	30	10	+0.087
MZ92-43	43	3.0	225	900	0.1	31	33	10	+0.088
MZ92-47	47	2.7	260	1000	0.1	34	36	10	+0.088
MZ92-51	51	2.5	300	1100	0.1	37	39	10	+0.089
MZ92-56	56	2.2	360	1300	0.1	41	43	10	+0.089
MZ92-60	60	2.1	410	1500	0.1	44	46	10	+0.090
MZ92-62	62	2.0	430	1600	0.1	45	47	10	+0.090
MZ92-68	68	1.8	520	1900	0.1	49	52	10	+0.090
MZ92-75	75	1.7	600	2300	0.1	53	56	10	+0.090
MZ92-82	82	1.5	700	2700	0.1	59	62	10	+0.090
MZ92-87	87	1.4	780	3100	0.1	65	68	10	+0.091
MZ92-91	91	1.4	840	3400	0.1	66	69	10	+0.091
MZ92-100	100	1.3	1000	4000	0.1	72	76	10	+0.091
MZ92-110	110	1.1	1200	5000	0.1	80	84	10	+0.091
MZ92-120	120	1.0	1400	5100	0.1	86	91	10	+0.092
MZ92-130	130	0.95	1600	5200	0.1	94	99	10	+0.092
MZ92-140	140	0.90	1800	5300	0.1	101	106	10	+0.092
MZ92-150	150	0.85	2100	5400	0.1	108	114	10	+0.092
MZ92-160	160	0.80	2300	5500	0.1	116	122	10	+0.092
MZ92-170	170	0.74	2600	5600	0.1	123	129	10	+0.092
MZ92-180	180	0.68	2900	6000	0.1	130	137	10	+0.092
MZ92-190	190	0.66	3200	6500	0.1	137	144	10	+0.093
MZ92-200	200	0.65	3500	7000	0.1	144	152	10	+0.093

NOTE 1 – TOLERANCE AND VOLTAGE DESIGNATION

Tolerance designation – The type numbers listed indicate a tolerance of ±20% with guaranteed limits on V_Z, I_R and V_F. In addition, zener impedance (Z_{ZT}, Z_{ZK}) limits are guaranteed on devices indicated by suffix "A" for ±10% tolerance, "B" for ±5.0%, "C" for ±2.0% and "D" for ±1.0% tolerance.

Non-Standard voltage designation – To designate units with zener voltages other than those assigned the Motorola type number should be used.

EXAMPLE:



NOTE 2 – SPECIAL SELECTIONS AVAILABLE INCLUDE:

(a) Nominal zener voltages between those shown.

(b) Matched sets: (Standard Tolerances are ±5.0%, ±2.0%, ±1.0%)

a. Two or more units for series connection with specified tolerance on total voltage. Series matched sets make zener voltages in excess of 200 volts possible as well as providing lower temperature coefficients, lower dynamic impedance and greater power handling ability.

b. Two or more units matched to one another with any specified tolerance.

(c) Tight voltage tolerances: 1.0%, 2.0%

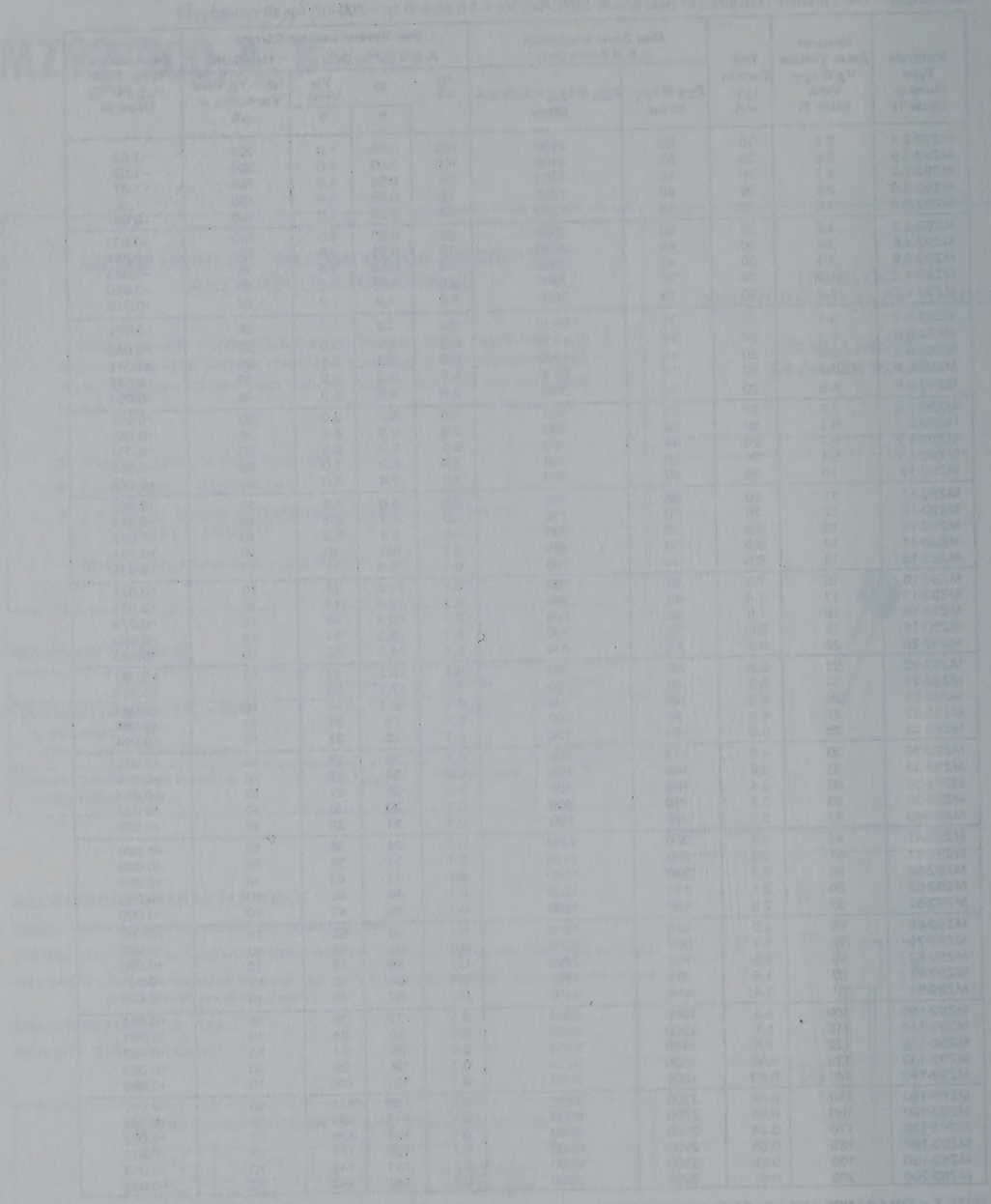
NOTE 3 – TYPICAL TEMPERATURE COEFFICIENT (θ_{VZ})

Test conditions for temperature coefficient are as follows:

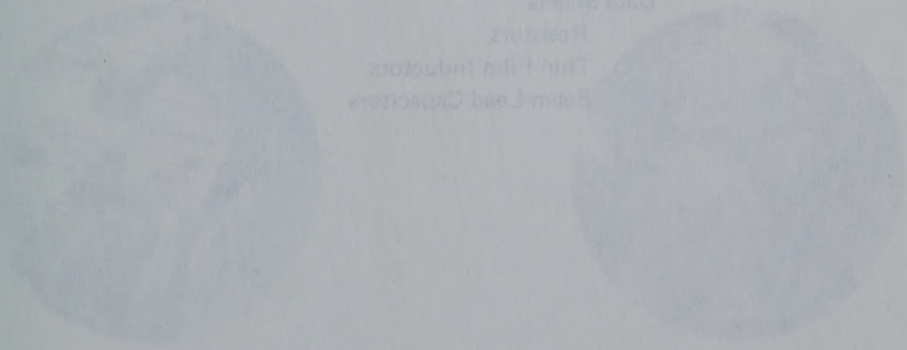
a. I_{ZT} = 7.5 mA, T_1 = 25°C.
T_2 = 125°C (MZ92-2.4A,B thru MZ92-12A,B).

b. I_{ZT} = Rated I_{ZT}, T_1 = 25°C.
T_2 = 125°C (MZ92-13A,B thru MZ92-200A,B).

Device to be temperature stabilized with current applied prior to reading breakdown voltage at the specified ambient temperature.



MICROCIRCUIT COMPONENTS



MICROCIRCUIT COMPONENTS

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TRANSISTOR AND SMALL-SIGNAL DIODE CHIPS

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- Data Sheets
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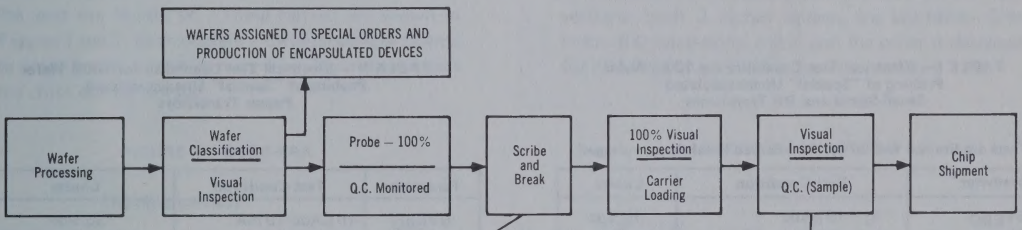
STANDARD CHIP PROCESSING

The transistor and small-signal diode "chips" in Motorola's Standard Microcircuit Components line are produced on the same well-proven production lines that provide Motorola's standard encapsulated devices. They are subjected to the same rigid in-process controls used to insure the reliability and performance of the eventual packaged components. In fact, as shown in the flow chart below, all wafer processing is completed before the wafers are assigned either for subsequent encapsulation or for additional special testing and handling involved in selling unencapsulated components.

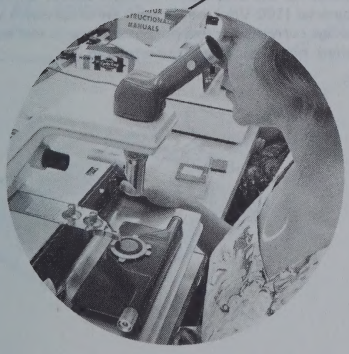
As with standard encapsulated products, the entire test and inspection sequence for chips is under the auspices of the Quality Control Department, providing independent quality assurance completely disassociated from production control.

CHIP PROCESSING AND QUALITY CONTROL SEQUENCE



Wafers are visually inspected for acceptable passivation and metalization

Chips are visually inspected and rejects removed. Typical rejection criteria:
- cracks intersecting active region
- ink marking indicating electrical rejects
- missing or smeared metalization
- exposed silicon



NON-STANDARD CHIP PROCESSING

The standard unencapsulated semiconductors described in the following sections meet a wide variety of application requirements. Nevertheless, there may be occasions when a designer can benefit from a non-standard device for a specific circuit. To satisfy these requirements, almost any device from Motorola's broad line of conventional packaged semiconductors may be obtained on a specially negotiated basis. Moreover, though the electrical specifications of these special chips are limited by certain test limitations, the customer can negotiate additional tests. Please contact your Motorola sales representative for more information.

On special order, Motorola transistors other than those listed in data sheets may be obtained in both wafer and chip form. The following tables list test limitations for these devices. The tests indicated can be made on a 100% basis. The tests can also be negotiated on a sampling basis.

Frequency and switching performance correspond to the inherent capability of a particular product line; dynamic specifications cannot be obtained by probing a chip. Such parameters are measured with the chip sealed in a standard encapsulated package and the resulting measurement includes the package parasitics.

TABLE I – Electrical Test Capability for 100% Wafer Probing of "Special" Unencapsulated Small-Signal and RF Transistors

(Tests are limited to 3 of the 4 indicated breakdown voltages)

Parameter*	Test Condition	Limits
BV_{EBO}	I_C = 10 μAdc	10 Vdc
BV_{CBO}	I_C = 100 μAdc	200 Vdc
BV_{CES}	I_C = 100 μAdc	200 Vdc
BV_{CEO}	I_C = 10 mAdc	200 Vdc
h_{FE}**	I_C = 1 mAdc to 150 mAdc V_{CE} = 0 to 20 Vdc	**

*In addition to the listed parameters, leakage current may be probed to limits no tighter than 20 nAdc.

**Choice of one h_{FE} test to a maximum and a minimum limit or two h_{FE} tests, each to a maximum or minimum limit.

TABLE II – Electrical Test Capability for 100% Wafer Probing of "Special" Unencapsulated Power Transistors

Parameter	Test Condition	Limits
BV_{EBO}	10 μAdc-10 mA	30 Vdc
BV_{CBO}	50 μAdc-5.0 mAdc	500 Vdc @ 1.0 mAdc
BV_{CES}	50 μAdc-1.0 mAdc	500 Vdc @ 1.0 mAdc
BV_{CEO}	1.0 mAdc-100 mAdc	500 Vdc @ 1.0 mAdc
h_{FE}	I_C = 50 mAdc-1.0 Adc V_{CE} = 1.0-20 Vdc	–

Minimum leakage currents will be the same as the minimum currents listed for the breakdown voltages above. On high voltage material (100 Vdc) we convert the breakdown voltage to leakage currents for test purposes. h_{FE} is test equipment limited, higher currents are correlated.

HANDLING PRECAUTIONS

Standard microcircuit components listed in the data sheets in this catalog are passivated devices, as are most special selections. However, many other unpackaged components, such as high power thyristors, silicon mesa power transistors and germanium power transistors, require special handling. Consequently their parameters cannot be guaranteed.

For passivated devices, although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published (or negotiated) specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are processed in a non-inert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed by semiconductor manufacturers.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

STANDARD CARRIER PACKAGES

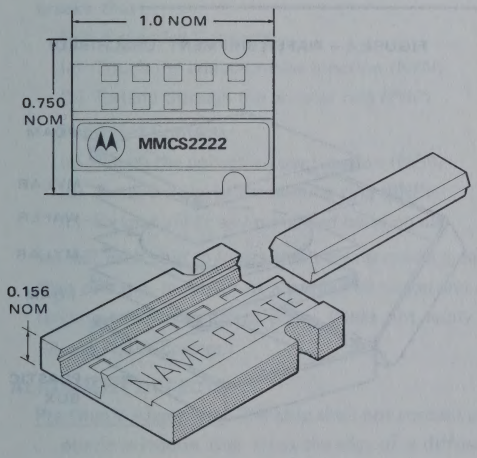
To accommodate customers with both small and large quantity requirements, Motorola supplies microcircuit components in two standard carriers, the Deka-Pak and the Multi-Pak. These carriers are shown in Figures 1 and 2. Both contain individual compartments to simplify user inventory recordkeeping and to protect the chips during storage.

The Deka-Pak holds 10 small-signal chips, and is ideal for prototype development.

The Multi-Pak is excellent for production use. Two versions, both 2 inches square, are available. One holds 400 small-signal chips, and the other is designed for 100 large chips such as power transistors.

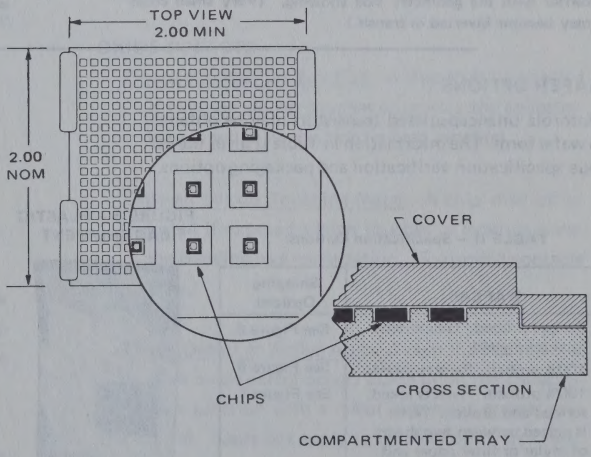
FIGURE 1 – DEKA-PAK

(10-chip carrier)



To accommodate the customer with limited quantity requirements, the Deka-Pak carrier contains individual compartments for 10 chips.

FIGURE 2 – MULTI-PAK



The Multi-Pak carrier is designed for production use. Two versions are available, one holding 400 small chips, and one holding 100 large chips such as those used for power transistors. All of the carriers are 2 inches square, and are vacuum sealed before shipment.

OPTIONAL SHIPPING METHODS

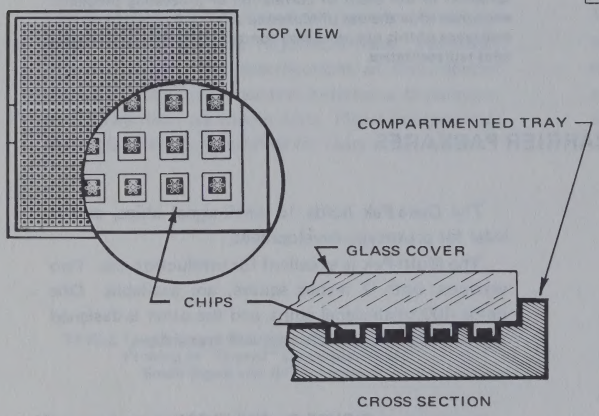
CHIP OPTIONS

For large quantity use, or special applications, shipping methods other than the standard Deka-Pak or Multi-Pak may be desired. Various packaging and shipping options are available on a negotiated basis. For more information on these options, please contact your Motorola sales representative.

TABLE I – Specification Options

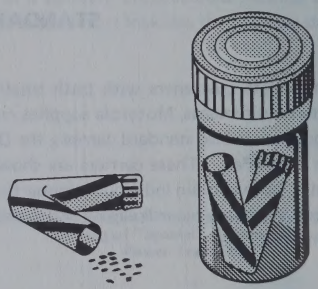
CHIPS	Shipping Options
1. 100% probed. Rejects inked but included in bulk shipment.	See Figure 4
2. 100% probed. Electrical and mechanical rejects removed.	See Figure 2 and Figure 3
3. Same as above, but sample tested in a package to meet negotiated acceptance criteria.	See Figure 2 and Figure 3

FIGURE 3 – K-PAK (1000-CHIP CARRIER)



This carrier holds 1000 chips. It is designed with individual compartments for each chip. The chips are placed in the carrier with the geometry side showing. (Very small chips may become inverted in transit.)

FIGURE 4 – STRAW-PAK PLASTIC VIAL BULK SHIPMENT



The Straw-Pak is a vial encompassing a straw that has one end closed. The chips are inserted in the straw, and then the straw is bent and placed in the plastic vial for shipment.

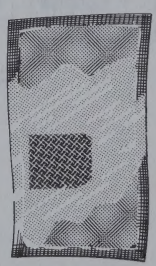
WAFER OPTIONS

Motorola unencapsulated transistors may be obtained in wafer form. The information in Table II gives the various specification verification and packaging options.

TABLE II – Specification Options

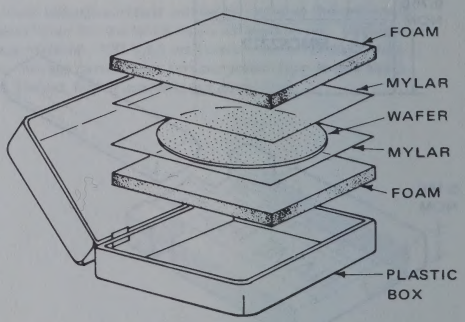
WAFERS	Shipping Options
1. Sample probed. Guaranteed minimum yield.	See Figure 6
2. 100% probed. Rejects inked.	See Figure 6
3. 100% probed. Rejects inked, scribed and broken. Wafer is placed between two sheets of mylar or filter paper and vacuum sealed in a plastic bag.	See Figure 5

FIGURE 5 – PLASTIC BAG SHIPMENT



Wafer is 100% probed. Rejects inked, scribed, and broken. Wafer is placed between two sheets of mylar and vacuum sealed in a plastic bag.

FIGURE 6 – WAFER SHIPMENT (UNSCRIBED)



Wafers are shipped between two layers of mylar, sandwiched between two layers of polyfoam pressed together in a plastic box. This prevents movement or damage to the wafer.

DEFINITION OF TERMS

Emitter-Base and Collector-Base Junctions. *The region where the base and collector, and the emitter and base meet. These junctions will be defined on the surface of the chip as an oxide step.*

Diffusion Window. *The opening etched through the oxide to permit the diffusion of the emitter and base.*

Active Junction. *A change in 'N' type to 'P' type doping or conversely, by a diffusion step. On discrete transistors there are 2 active junctions, the collector-base junction and the emitter-base junction.*

The Pre-Ohmic Window. *The opening etched through the oxide for metalization contact to the emitter and base regions.*

Pre-Ohmic Alignment. *The positioning of the oxide opening into which the metalization is placed.*

Passivated Region. *Any region covered by glass ($Si\ 0_2$), nitride, or other protective dielectric.*

Expanded Contact. *Any pattern that has metalization crossing a diffused junction.*

Attached Foreign Material. *A foreign substance that cannot be removed when subjected to a nominal gas flow. Lint, silicon dust, etc. are not considered attached since they can be removed after die mount.*

INSPECTION CRITERIA

Visual inspection is performed with a microscope using 40X-80X magnification for Silicon-Power Chips and 100X-125X for other devices.

SCRIBING DEFECTS

Excess Chip. A chip shall be rejected if a portion of an adjacent chip with metalization is still attached to subject chip.

Scribe Line Limits. A chip shall be rejected if a scribe line touches or crosses an active junction area or a metalized region.

MECHANICAL DEFECTS

Inspect each chip to insure there are no cracks or breaks that:

Non-Expanded Contacts

(a) Touch the collector-base junction (NPN).

(b) Extend through the annular ring (PNP).

Expanded Contacts

(a) Touch the collector-base junction (NPN).

(b) Extend through the annular ring (PNP).

(c) Extend under any metalized bonding pad.

Inspect each chip to insure there are no cracks greater than one mil. in length in a passivated region and extending toward an active area. (Does not apply to Silicon Power devices.)

ALIGNMENT DEFECTS

Pre-Ohmic Alignment. The chip shall not contain pre-ohmic windows that cross the edge of a diffusion window.

Diffusion Window Alignment. No diffusion window shall touch another diffusion window.

Metalization Alignment. The metalization must be aligned so that at least 50% of the pre-ohmic window is covered with metalization.

FOREIGN MATERIAL DEFECTS

Bridged-Across Metal. A chip shall be rejected when attached foreign material bridges across normally separated metalized areas.

Particle Size Inside Active Area. A chip shall be rejected when attached foreign material greater than 2 mils. is found inside collector-base junction or on the emitter-base bonding pads.

OXIDE DEFECTS

Exposed Silicon on Junction. A chip shall be rejected if exposed silicon touches or crosses the collector-base junction or the emitter-base junction.

Exposed Silicon Touching Metal. A chip shall be rejected if exposed silicon touches or extends under the bonding pad metalization. (Expanded contacts only.)

Oxide Defect in Active Area. A chip shall be rejected if an oxide defect occurs inside or on the collector-base junction with a major dimension greater than 1 mil. (Does not apply to Silicon Power Devices.)

Oxide Defect Crossing or Touching. A chip shall be rejected if gross oxide defects, evidenced by alternately colored bands (rainbow effect), emit from two separate ohmic contacts and either touch or cross each other, or cross the collector-base junction.

INSPECTION CRITERIA (continued)

Oxide Defect Under Bonding Pads. A chip shall be rejected if an oxide defect extends under 25% of the bonding pad.

METALIZATION DEFECTS

Expanded Contacts (finger geometries).

Missing Metalization on Bonding Pads. A chip shall be rejected when 25% of the metalization is missing from a bonding pad.

Metalization Width at Oxide Step. Any chip shall be rejected if the metalization width of any finger is reduced greater than 25% at any oxide step. 75% of the metal width must remain.

Metalization Width In First 50 Percent of Finger. A chip shall be rejected if the finger metalization is narrower than 50% of its original design width or if the finger width is reduced greater than 50% due to a severe scratch or void in the first 50% of the finger. A severe scratch is one which exposes the underlying surface.

Fingers Isolated or Missing. A chip shall be rejected if any finger is not 100% continuous over the first 50% of the finger (from the bonding pad).

Bubbled Metalization. A chip shall be rejected if it exhibits any bubbled metalization on a bonding pad.

Lifted Metalization. A chip shall be rejected if it exhibits any lifted metalization. Slight undercutting causing a lifted appearance is not cause for rejection.

Bridged Metalization. A chip shall be rejected for bridged metal shorting any two normally separated metalized areas.

Metal Corrosion. A chip shall be rejected if it exhibits any corroded metal. Corrosion is a chemical reaction or process causing abnormalities in the metalization. A rough metalization surface is not to be considered corrosion.

Non-Expanded Contacts

Missing Metalization. A chip shall be rejected when more than 25% of the metalization is missing from a bonding pad.

Lifted Metalization. A chip shall be rejected if it exhibits any lifted metalization. Slight undercutting causing a lifted appearance is not cause for rejection.

Bubbled Metalization. A chip shall be rejected if it exhibits any bubbled metalization on a bonding pad.

Bridged Metalization. A chip shall be rejected for bridged metal shorting any two normally separated metalized areas.

Narrow Metal Widths In Relation To Design Width. A chip shall be rejected if the metalization is narrower than 50% of its original design width.

Metal Corrosion. A chip shall be rejected if it exhibits any corroded metal. Corrosion is a chemical reaction or process causing abnormalities in the metalization. A rough metalization surface is not to be considered corrosion.

METALIZED ANNULAR RING

Missing Metalization. A chip shall be rejected when a metalized annular ring is not 100% continuous.

Bridged Metalization. A chip shall be rejected for bridged metal shorting the metalized annular ring with any other metalized area.

RECOMMENDED INCOMING INSPECTION PROCEDURES

Motorola assures that the devices will meet the customers' incoming visual inspection when inspected to the visual criteria and LTPD limits specified in the data sheet. Inspection must be performed at the power and magnification indicated. Motorola guarantees dc parameters to LTPD limits specified in the data sheet.

Returned Components

It is suggested that the customer perform incoming inspection in the following sequence:

1. Visual
2. Test dc electrical parameters

A. If the lot fails visual inspection, containers must be closed and secured and the entire lot returned to Motorola with a detailed inspection report. In no case will Motorola accept rejected material that the customer has inspected 100%.

B. After the lot has passed incoming visual inspection, samples are selected and subjected to electrical tests of the dc parameters. If samples do not pass the electrical tests, they shall be packaged separately and identified with all the information from the original package of chips. The shipping container must be closed and secured. The entire lot together with the test samples and a detailed inspection report shall be returned to Motorola. In no case will Motorola accept rejected material that the customer has inspected 100%.

SILICON TRANSISTORS

UNENCAPSULATED AMPLIFIER TRANSISTORS

. . . with passivated Annular construction that provides high reliability and consistent performance. These chips are identical to the chips used in packaged Motorola transistors with 2N prefixes; i.e., the MMCS910 chip is used in the Motorola 2N910 transistor. For more detailed characteristic data, please refer to the equivalent Motorola 2N. . . . data sheet.

- DC Current Gains to 300 Minimum
- Breakdown Voltages to 100 Volts
- Noise Figures as Low as 0.8 dB Typical

MMCS910
MMCS918
MMCS929
MMCS930
MMCS2483
MMCS2484
MMCS3798
MMCS3799
MMCS5087
MMCS5088

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C mA	Geometry
NPN					
MMCS910	60	100	7.0	—	1
MMCS918	15	30	3.0	50	2
MMCS929	45	45	5.0	30	3
MMCS930	45	45	5.0	30	3
MMCS2483	60	60	6.0	50	3
MMCS2484	60	60	6.0	50	3
MMCS5088	30	35	4.5	50	5
PNP					
MMCS3798	60	60	5.0	50	4
MMCS3799	60	60	5.0	50	4
MMCS5087	30	50	3.0	50	4

Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

AMPLIFIER TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C Volts min	mA	BV_{CBO} @ I_C Volts min	μA	BV_{EBO} @ I_E Volts min	μA	I_{CBO} @ V_{CB} nA max	Volts	h_{FE} @ I_C min/max	μA mA *	$V_{CE(sat)}$ & $V_{BE(sat)}$ @ I_C Volts max	Volts max	mA
NPN													
MMCS910	60	30	100	100	7.0	100	25	75	75/–	10*	0.4	0.8	10
MMCS918	15	3.0	30	1.0	3.0	10	10	15	20/–	3.0*	0.4	1.0	10
MMCS929	45	10	45	10	5.0	10	10	45	60/–	500	1.0	1.0	10
MMCS930	45	10	45	10	5.0	10	10	45	150/–	500	1.0	1.0	10
MMCS2483	60	10	60	10	6.0	10	10	45	75/–	100	0.35	–	1.0
MMCS2484	60	10	60	10	6.0	10	10	45	175/–	100	0.35	–	1.0
MMCS5088	30	1.0	35	100	4.5	10	50	20	300/900	100	0.5	–	10
PNP													
MMCS3798 ①	60	10	60	10	5.0	10	10	50	150/450	500	0.25	0.8	1.0
MMCS3799 ①	60	10	60	10	5.0	10	10	50	300/900	500	0.25	0.8	1.0
MMCS5087	30	1.0	50	100	3.0	10	50	35	250/800	100	0.3	–	10

AC* PARAMETERS

TYPE	C_{ob} pF max	C_{ib} pF max	$\|h_{fe}\|$ @ min	I_C mA	V_{CE} Volts	f MHz	NF @ dB max	f Hz
NPN								
MMCS910	15	85	2.5	50	10	20	14	1.0 K
MMCS918	1.7	2.0	6.0	4.0	10	100	6.5	60 M
MMCS929	8.0	–	1.0	0.5	5.0	30	5.0	10-15.7 K
MMCS930	8.0	–	1.0	0.5	5.0	30	4.0	10-15.7 K
MMCS2483	6.0	8.0	2.0	0.5	5.0	30	5.0	10-15.7 K
MMCS2484	6.0	8.0	2.0	0.5	5.0	30	4.0	10-15.7 K
MMCS5088	–	–	2.0	0.5	5.0	20	4.0	10-15.7 K
PNP								
MMCS3798 ①	4.0	–	0.8	0.5	5.0	30	1.0 typ	1.0 K
MMCS3799 ①	4.0	–	0.8	0.5	5.0	30	0.8 typ	1.0 K
MMCS5087	4.0	–	1.6	0.5	5.0	20	3.0	10-15.7 K

① SMALL-SIGNAL CHARACTERISTICS

(I_C = 1.0 mA, V_{CE} = 10 V, f = 1.0 kHz.)

TYPE	h_{ie} k ohms min/max	h_{re} x 10^{-4} max	h_{oe} μmhos min/max
PNP			
MMCS3798	2.4/18	30	4.0/70
MMCS3799	8.0/48	30	4.0/70

*AC parameter values are as specified in the standard 2N data sheets. (encapsulated devices).

PARAMETER LIMITATIONS AND WARRANTY

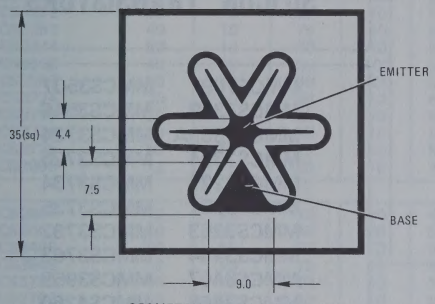
Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

AMPLIFIER TRANSISTORS (continued)

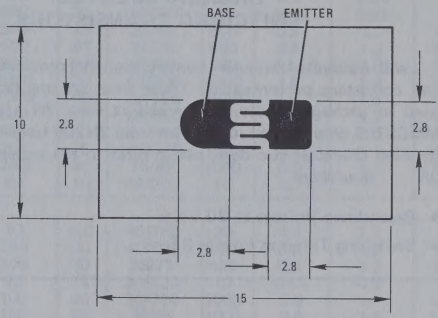
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

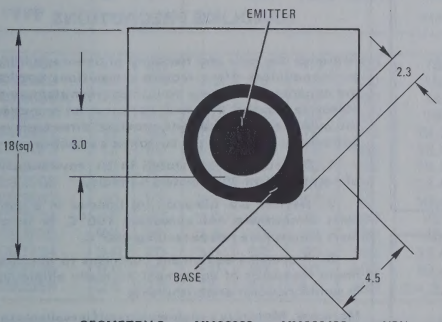
ALL DIMENSIONS ARE IN MILS



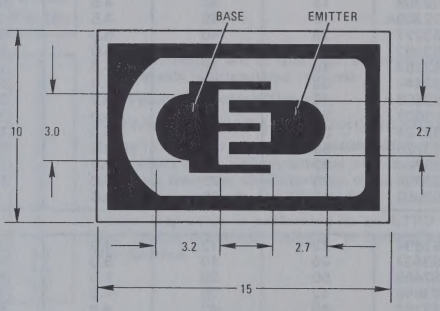
GEOMETRY 1 MMCS910 NPN



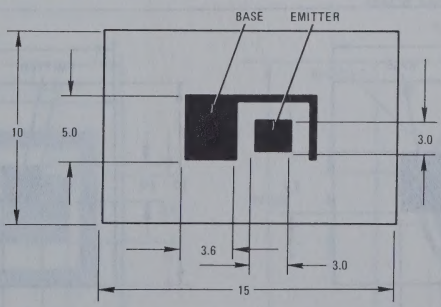
GEOMETRY 2 MMCS918 NPN



GEOMETRY 3 MMCS929 MMCS930 MMCS2483 MMCS2484 NPN



GEOMETRY 4 MMCS3798 MMCS3799 MMCS5087 PNP



GEOMETRY 5 MMCS5088 NPN

UNENCAPSULATED SWITCHING TRANSISTORS

. . . with passivated Annular construction that provides high reliability and consistent performance. These chips are identical to the chips used in packaged Motorola transistors with 2N prefixes; i.e., the MMCS709 chip is used in the Motorola 2N709 transistor. For more detailed characteristic data, please refer to the equivalent Motorola 2N. . . . data sheet.

- Breakdown Voltage to 80 Volts
- Switching Times as Low as 3.5 ns

SILICON TRANSISTORS

MMCS709
MMCS2369
MMCS2369A
MMCS2894
MMCS3227
MMCS3252
MMCS3253
MMCS3444
MMCS3467
MMCS3468
MMCS3506
MMCS3507
MMCS3546
MMCS3724
MMCS3725
MMCS3734
MMCS3735
MMCS3762
MMCS3763
MMCS3959
MMCS4260

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C Peak† mA	Geometry
NPN					
MMCS709	6.0	15	4.0	100	1
MMCS2369	15	40	4.5	500†	2
MMCS2369A	15	40	4.5	200	2
MMCS3227	20	40	6.0	500†	2
MMCS3252	30	60	5.0	1000	4
MMCS3253	40	75	5.0	1000	4
MMCS3444	50	80	5.0	1000	4
MMCS3506	40	60	5.0	3000	6
MMCS3507	50	80	5.0	3000	6
MMCS3724	30	50	6.0	1000	4
MMCS3725	50	80	6.0	1000	4
MMCS3734	30	50	5.0	1500	8
MMCS3735	50	75	5.0	1500	8
MMCS3959	12	20	4.5	30	9
PNP					
MMCS2894	12	12	4.0	200	3
MMCS3467	40	40	5.0	1000	5
MMCS3468	50	50	5.0	1000	5
MMCS3546	12	15	4.5	200	7
MMCS3762	40	40	5.0	1500	5
MMCS3763	60	60	5.0	1500	5
MMCS4260	15	15	4.5	30	10

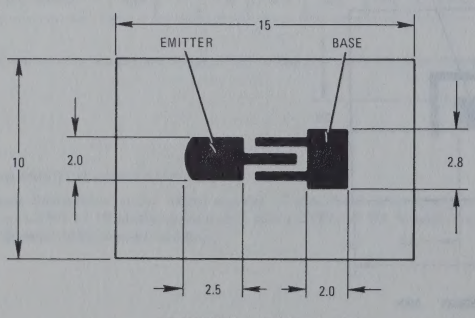
Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

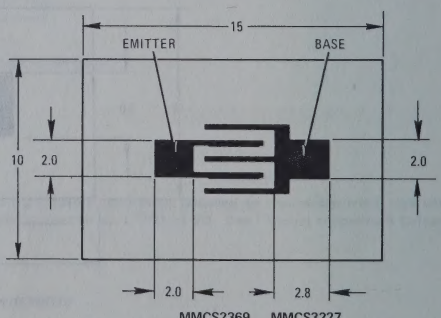
Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in a non-inert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.



GEOMETRY 1 MMCS709 NPN



GEOMETRY 2 MMCS2369 MMCS3227 NPN
MMCS2369A

SWITCHING TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C Volts min	mA	BV_{CBO} @ I_C Volts min	μA	BV_{EBO} @ I_E Volts min	μA	I_{CBO} @ V_{CB} nA max	Volts	h_{FE} @ I_C min/max	mA	$V_{CE(sat)}$, $V_{BE(sat)}$ @ I_C Volts max	Volts max	mA
NPN													
MMCS709	6.0	10	15	10	4.0	10	50	5.0	20/200	10	0.35	0.85	3.0
MMCS2369	15	10	40	10	4.5	10	400	20	40/120	10	0.25	0.85	10
MMCS2369A	15	10	40	10	4.5	10	400	20	30/–	30	0.2	0.85	10
MMCS3227	20	10	40	10	6.0	10	200	20	100/300	10	0.25	0.85	10
MMCS3252	30	10	60	10	5.0	10	500	40	30/90	500	0.5	1.3	500
MMCS3253	40	10	75	10	5.0	10	500	60	25/75	500	0.6	1.3	500
MMCS3444	50	10	80	10	5.0	10	500	60	20/60	500	0.6	1.3	500
MMCS3506	40	10	60	100	5.0	10	1000	30	40/200	1500	1.0	1.4	1500
MMCS3507	50	10	80	100	5.0	10	1000	40	30/150	1500	1.0	1.4	1500
MMCS3724	30	10	50	10	6.0	10	500	40	60/150	100	0.42	1.2	500
MMCS3725	50	10	80	10	6.0	10	500	60	60/150	100	0.42	1.2	500
MMCS3734	30	10	50	10	5.0	10	200	25	30/120	1000	0.5	1.2	500
MMCS3735	50	10	75	10	5.0	10	200	40	20/80	1000	0.5	1.2	500
MMCS3959	12	10	20	10	4.5	10	50	10	40/200	10	0.2	–	1.0
PNP													
MMCS2894	12	10	12	10	4.0	10	10	6.0	40/150	30	0.2	1.2	30
MMCS3467	40	10	40	10	5.0	10	100	30	40/120	500	0.5	1.2	500
MMCS3468	50	10	50	10	5.0	10	100	30	25/75	500	0.6	1.2	500
MMCS3546	12	10	15	10	4.5	10	10	10	30/120	10	0.15	0.9	10
MMCS3762	40	10	40	10	5.0	10	100	30	30/120	1000	0.9	1.4	1000
MMCS3763	60	10	60	10	5.0	10	100	50	20/80	1000	0.9	1.4	1000
MMCS4260	15	10	15	10	4.5	10	50	12	30/150	10	0.35	1.0	10

AC* PARAMETERS

TYPE	C_{ob} pF max	C_{ib} pF max	$\lvert h_{fe} \rvert$ @ I_C min	mA	V_{CE} Volts	f MHz	t_d, t_r t_{on}* ns max	t_s, t_f t_{off}* ns max	Test Circuit Fig. No.
NPN									
MMCS709	3.0	2.0	5.0	5.0	4.0	100	18*	18*	1
MMCS2369	4.0	4.0	5.0	10	10	100	15*	20*	2
MMCS2369A	4.0	–	5.0	10	10	100	14*	20*	3
MMCS3227	4.0	4.0	5.0	10	10	100	15*	20*	2
MMCS3252	12	80	1.8	50	10	100	18,35	50,35	5
MMCS3253	12	80	1.5	50	10	100	18,40	50,35	5
MMCS3444	12	80	1.5	50	10	100	18,40	50,35	5
MMCS3506	40	300	2.5	100	5.0	20	18,40	65,40	7
MMCS3507	40	300	2.5	100	5.0	20	18,40	65,40	7
MMCS3724	12	70	2.0	50	10	100	45*	75*	9
MMCS3725	10	70	2.0	50	10	100	45*	75*	9
MMCS3734	9.0	80	2.0	50	10	100	10,45	35,35	10
MMCS3735	9.0	80	2.0	50	10	100	10,45	35,35	10
MMCS3959	2.5	2.5	11	5.0	4.0	100	2.4,3.0(1)	1.6,3.3(1)	12
PNP									
MMCS2894	6.0	6.0	3.2	30	10	100	70*	100*	4
MMCS3467	25	100	1.6	50	10	100	10,30	80,30	6
MMCS3468	25	100	1.4	50	10	100	10,30	80,30	6
MMCS3546	6.0	6.0	7.0	10	10	100	48*	35*	8
MMCS3762	18	95	1.5	50	10	100	10,40	95,40	11
MMCS3763	18	95	1.2	50	10	100	10,40	95,40	11
MMCS4260	2.5	2.5	10	5.0	4.0	100	1.0,0.5(1)	1.0,1.0(1)	13

*AC parameters are as specified in the standard 2N data sheets (encapsulated devices)

(1) Typical Switching Times

PARAMETER LIMITATIONS AND WARRANTY

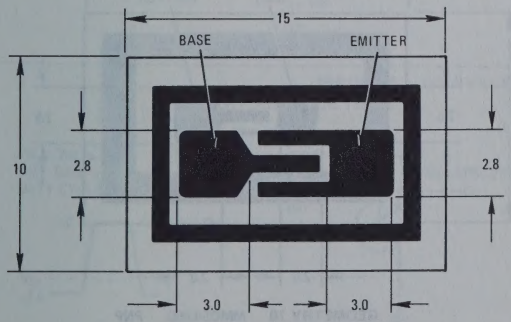
Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20.

Visual Inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

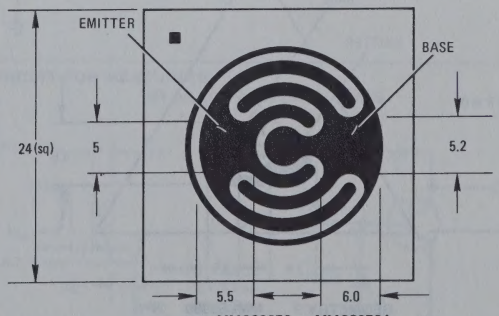
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 3 MMCS2894 PNP

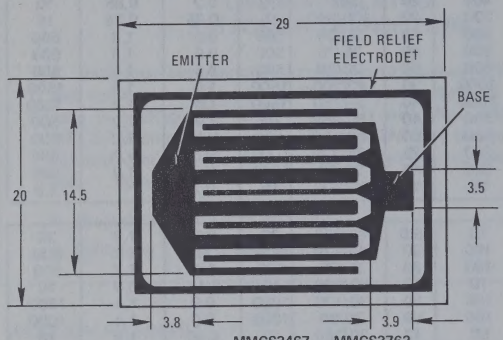


GEOMETRY 4 MMCS3252 MMCS3253 MMCS3444 MMCS3724 MMCS3725 NPN

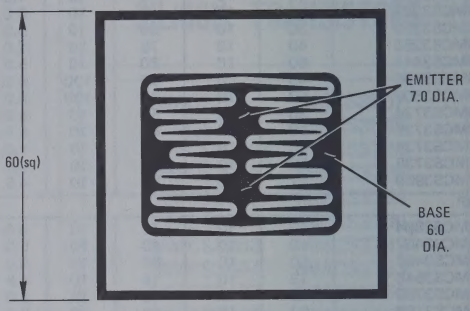
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

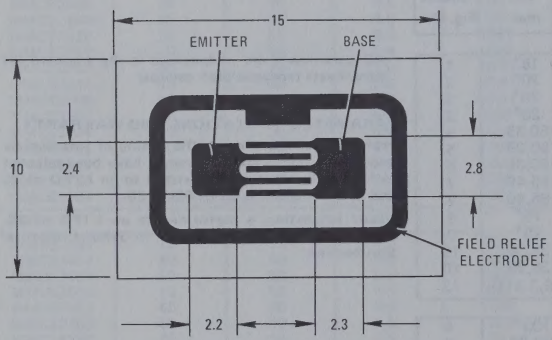
ALL DIMENSIONS ARE IN MILS



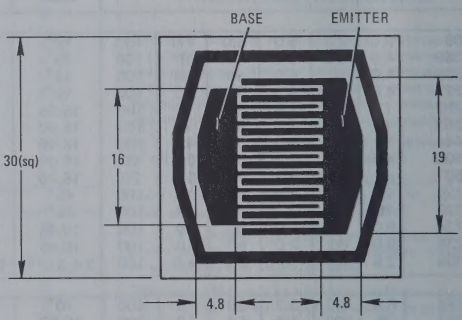
GEOMETRY 5 MMCS3467 MMCS3468 MMCS3762 MMCS3763 PNP



GEOMETRY 6 MMCS3506 MMCS3507 NPN



GEOMETRY 7 MMCS3546 PNP



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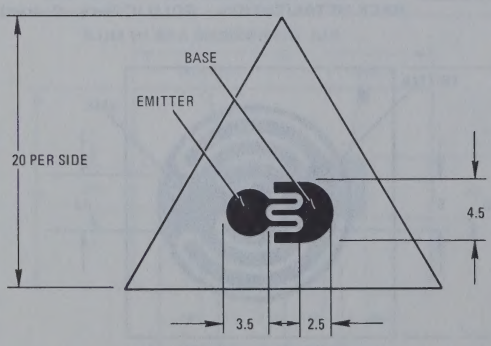
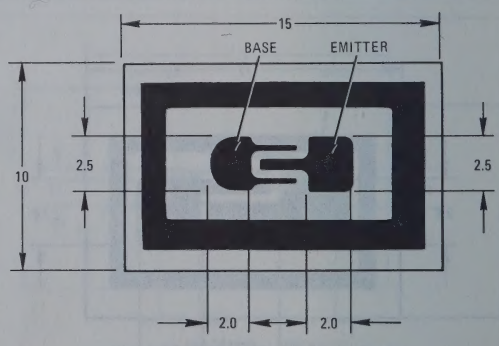


GEOMETRY 9 MMCS3959 NPN



GEOMETRY 10 MMCS4260 PNP

†Patented by Motorola – Patent No. 3,302,076

TEST CIRCUITS

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

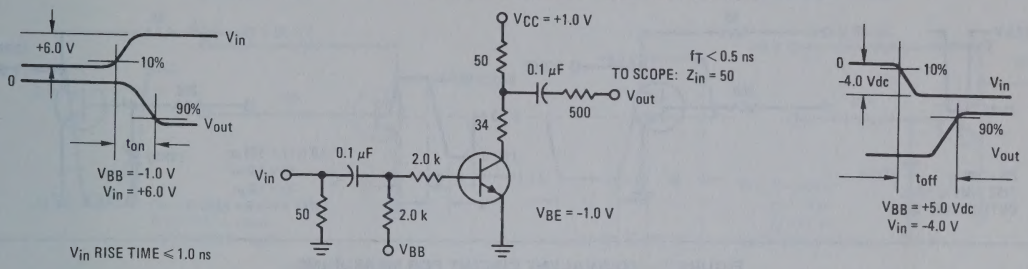
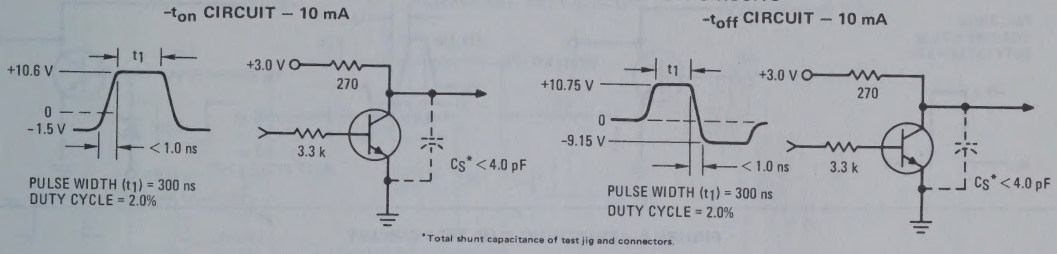
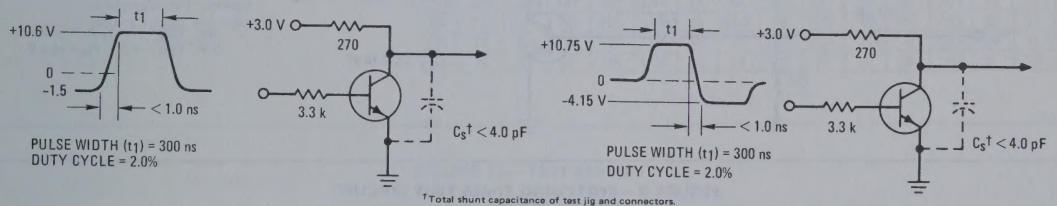


FIGURE 2 – SWITCHING TIME EQUIVALENT TEST CIRCUITS



*Total shunt capacitance of test jig and connectors.

FIGURE 3 – SWITCHING TIME EQUIVALENT TEST CIRCUITS



†Total shunt capacitance of test jig and connectors.

FIGURE 4 – SWITCHING TIME TEST CIRCUIT

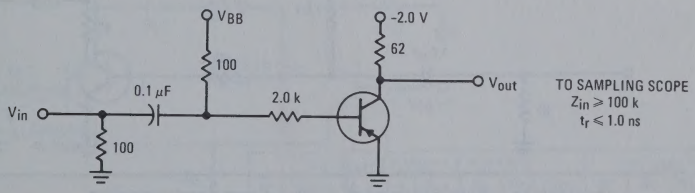
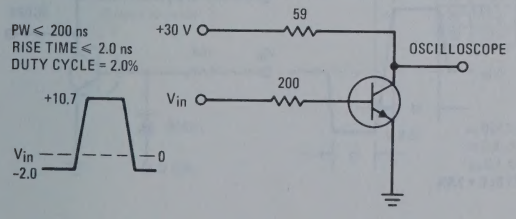


FIGURE 5 – EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIMES



STORAGE AND FALL TIMES

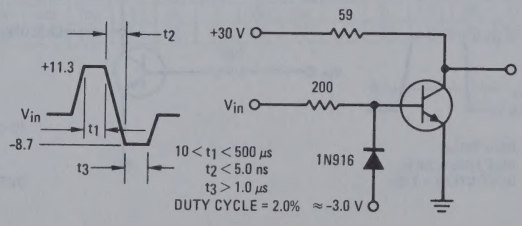


FIGURE 6 – EQUIVALENT TEST CIRCUT

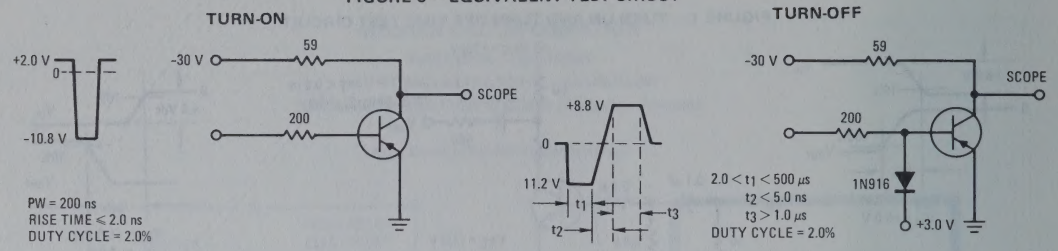


FIGURE 7 – EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIMES AND STORAGE AND FALL TIMES

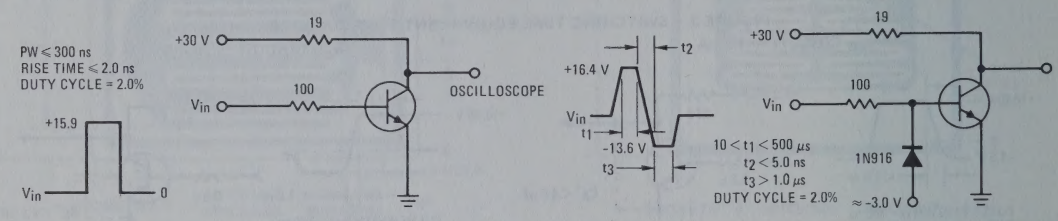


FIGURE 8 – SWITCHING TIME TEST CIRCUIT

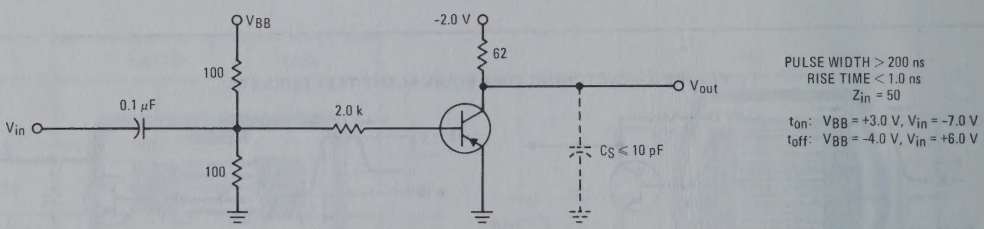


FIGURE 9 – SWITCHING TIMES TEST CIRCUIT

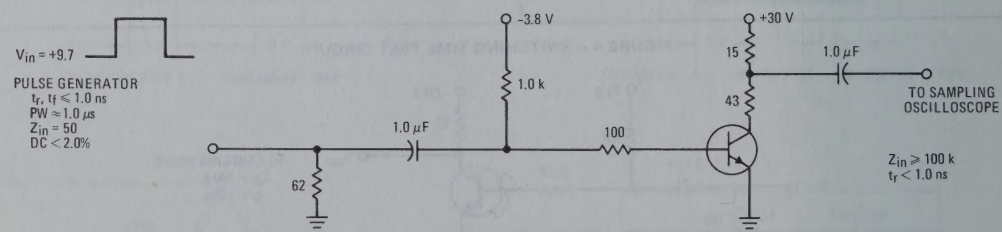


FIGURE 10 – SWITCHING TIME EQUIVALENT TEST CIRCUITS

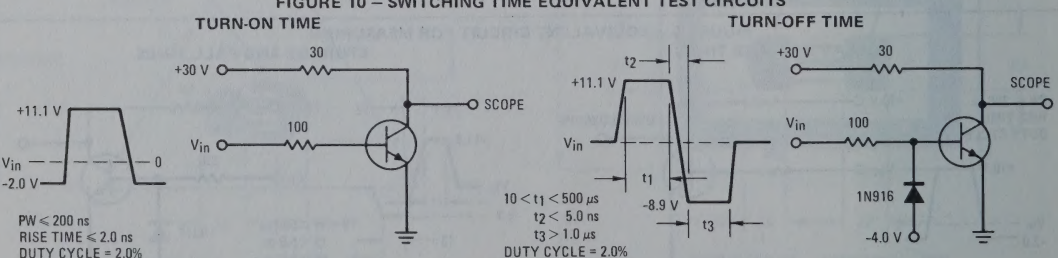


FIGURE 11 – SWITCHING TIME EQUIVALENT TEST CIRCUITS

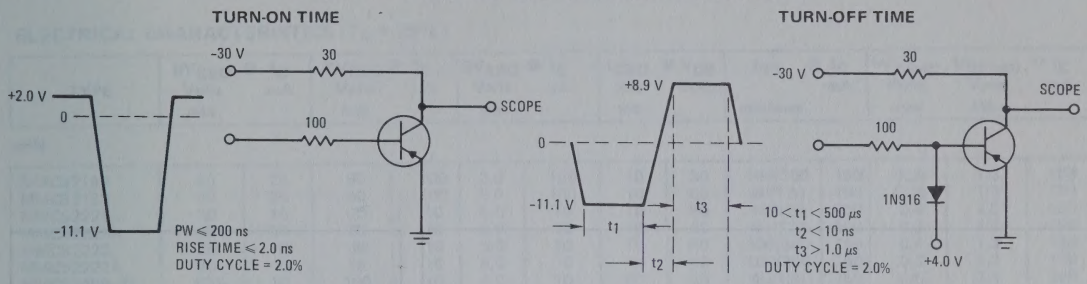
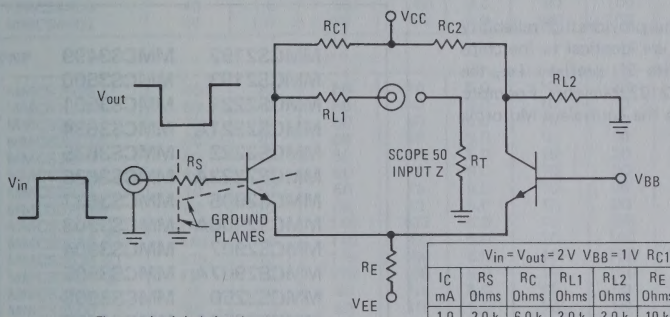


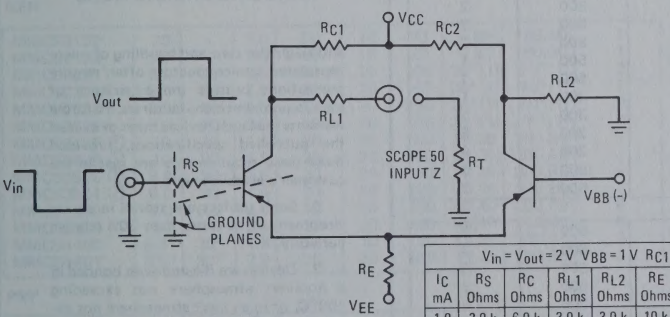
FIGURE 12 – TEST CIRCUIT



The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

$V_{in} = V_{out} = 2\ V$ $V_{BB} = 1\ V$ $R_{C1} = R_{C2}$								$V_{in} = V_{out} = 1\ V$ $V_{BB} = 0.5\ V$ $R_{C1} = R_{C2}$						
I_C mA	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts
1.0	2.0 k	6.0 k	3.0 k	3.0 k	10 k	10	16	1.0 k	6.0 k	1.2 k	1.2 k	24 k	24	32
5.0	360	3.56 k	400	450	2.0 k	10	47	175	1.0 k	200	250	3.0 k	15	27
10	160	1.0 k	200	250	3.0 k	30	26.3	75	300	100	150	3.0 k	30	17
20	62	300	100	150	1.0 k	20	16	25	150	25	75	1.0 k	20	11
30	28	157	66	116	1.0 k	30	13	8.0	77	0	50	1.0 k	30	9.0

FIGURE 13 – TEST CIRCUIT



The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

$V_{in} = V_{out} = 2\ V$ $V_{BB} = 1\ V$ $R_{C1} = R_{C2}$								$V_{in} = V_{out} = 1\ V$ $V_{BB} = 0.5\ V$ $R_{C1} = R_{C2}$						
I_C mA	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts	R_S Ohms	R_C Ohms	R_{L1} Ohms	R_{L2} Ohms	R_E Ohms	V_{EE} Volts	V_{CC} Volts
1.0	2.0 k	6.0 k	3.0 k	3.0 k	10 k	10	16	1.0 k	6.0 k	1.2 k	1.2 k	24 k	24	32
5.0	360	3.56 k	400	450	2.0 k	10	47	175	1.0 k	200	250	3.0 k	15	27
10	160	1.0 k	200	250	3.0 k	30	26.3	75	300	100	150	3.0 k	30	17
20	62	300	100	150	1.0 k	20	16	25	150	25	75	1.0 k	20	11
30	28	157	66	116	1.0 k	30	13	8.0	77	0	50	1.0 k	30	9.0

UNENCAPSULATED SWITCHING AND AMPLIFIER TRANSISTORS

. . . with passivated Annular construction that provides high reliability and consistent performance. These chips are identical to the chips used in packaged Motorola transistors with 2N prefixes; i.e., the MMCS2192 chip is used in the Motorola 2N2192 transistor. For more detailed characteristic data, please refer to the equivalent Motorola 2N. . . . data sheet.

- DC Current Gain to 100 Minimum
- Breakdown Voltages to 175 Volts
- f_T to 300 MHz

SILICON TRANSISTORS

MMCS2192 MMCS3499
MMCS2193 MMCS3500
MMCS2221 MMCS3501
MMCS2221A MMCS3634
MMCS2222 MMCS3635
MMCS2222A MMCS3636
MMCS2906 MMCS3637
MMCS2906A MMCS3903
MMCS2907 MMCS3904
MMCS2907A MMCS3905
MMCS3250 MMCS3906
MMCS3250A MMCS4400
MMCS3251 MMCS4401
MMCS3251A MMCS4402
MMCS3498 MMCS4403

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C mA	Geometry
NPN					
MMCS2192	40	60	5.0	1000	1
MMCS2193	50	80	8.0	1000	1
MMCS2221	30	60	5.0	800	2
MMCS2221A	40	75	6.0	800	2
MMCS2222	30	60	5.0	800	2
MMCS2222A	40	75	6.0	800	2
MMCS3498	100	100	6.0	500	1
MMCS3499	100	100	6.0	500	1
MMCS3500	150	150	6.0	300	1
MMCS3501	150	150	6.0	300	1
MMCS3903	40	60	6.0	200	6
MMCS3904	40	60	6.0	200	6
MMCS4400	40	60	6.0	600	7
MMCS4401	40	60	6.0	600	7
PNP					
MMCS2906	40	60	5.0	600	3
MMCS2906A	60	60	5.0	600	3
MMCS2907	40	60	5.0	600	3
MMCS2907A	60	60	5.0	600	3
MMCS3250	40	50	5.0	200	5
MMCS3250A	60	60	5.0	200	5
MMCS3251	40	50	5.0	200	5
MMCS3251A	60	60	5.0	200	5
MMCS3634	140	140	5.0	1000	4
MMCS3635	140	140	5.0	1000	4
MMCS3636	175	175	5.0	1000	4
MMCS3637	175	175	5.0	1000	4
MMCS3905	40	40	5.0	200	5
MMCS3906	40	40	5.0	200	5
MMCS4402	40	40	5.0	600	8
MMCS4403	40	40	5.0	600	8

Operating and Storage Junction Temperature Range −65 to +200°C

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

SWITCHING & AMPLIFIER TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C Volts / mA min	BV_{CBO} @ I_C Volts / µA min	BV_{EBO} @ I_E Volts / µA min	I_{CBO} @ V_{CB} nA / Volts max	h_{FE} @ I_C mA min/max		$V_{CE(sat)}$, $V_{BE(sat)}$ @ I_C Volts max / Volts max / mA
NPN							
MMCS2192	40 25	60 100	5.0 100	10 30	100/300	150	0.35 1.3 150
MMCS2193	50 25	80 100	8.0 100	10 60	40/120	150	0.35 1.3 150
MMCS2221	30 10	60 10	5.0 10	10 50	40/120	150	0.4 1.3 150
MMCS2221A	40 10	75 10	6.0 10	10 60	40/120	150	0.3 1.2 150
MMCS2222	30 10	60 10	5.0 10	10 50	100/300	150	0.4 1.3 150
MMCS2222A	40 10	75 10	6.0 10	10 60	100/300	150	0.3 1.2 150
MMCS3498 ①	100 10	100 10	6.0 10	50 50	40/120	150	0.6 1.4 300
MMCS3499 ①	100 10	100 10	6.0 10	50 50	100/300	150	0.6 1.4 300
MMCS3500 ①	150 10	150 10	6.0 10	50 75	40/120	150	0.4 1.2 150
MMCS3501 ①	150 10	150 10	6.0 10	50 75	100/300	150	0.4 1.2 150
MMCS3903	40 1.0	60 10	6.0 10	50 30	50/150	10	0.2 0.85 10
MMCS3904	40 1.0	60 10	6.0 10	50 30	100/300	10	0.2 0.85 10
MMCS4400	40 1.0	60 100	6.0 100	100 35	50/150	150	0.4 0.95 150
MMCS4401	40 1.0	60 100	6.0 100	100 35	100/300	150	0.4 0.95 150
PNP							
MMCS2906	40 10	60 10	5.0 10	20 50	40/120	150	0.4 1.3 150
MMCS2906A	60 10	60 10	5.0 10	10 50	40/120	150	0.4 1.3 150
MMCS2907	40 10	60 10	5.0 10	20 50	100/300	150	0.4 1.3 150
MMCS2907A	60 10	60 10	5.0 10	10 50	100/300	150	0.4 1.3 150
MMCS3250	40 10	50 10	5.0 10	20 40	50/150	10	0.25 0.9 10
MMCS3250A	60 10	60 10	5.0 10	20 40	50/150	10	0.25 0.9 10
MMCS3251	40 10	50 10	5.0 10	20 40	100/300	10	0.25 0.9 10
MMCS3251A	60 10	60 10	5.0 10	20 40	100/300	10	0.25 0.9 10
MMCS3634 ①	140 10	140 100	5.0 10	100 100	50/150	50	0.5 0.9 50
MMCS3635 ①	140 10	140 100	5.0 10	100 100	100/300	50	0.5 0.9 50
MMCS3636 ①	175 10	175 100	5.0 10	100 100	50/150	50	0.5 0.9 50
MMCS3637 ①	175 10	175 100	5.0 10	100 100	100/300	50	0.5 0.9 50
MMCS3905	40 1.0	40 10	5.0 10	50 30	50/150	10	0.25 0.85 10
MMCS3906	40 1.0	40 10	5.0 10	50 30	100/300	10	0.25 0.85 10
MMCS4402	40 1.0	40 100	5.0 100	100 35	50/100	150	0.4 0.95 150
MMCS4403	40 1.0	40 100	5.0 100	100 35	100/300	150	0.4 0.95 150

AC* PARAMETERS

TYPE	C_{ob} C_{cb}* pF max	C_{ib} C_{eb}* pF max	$\|h_{fe}\|$ @ I_C, V_{CE}, f min / mA / Volts / MHz	t_d, t_r t_{on}* ns max	t_s, t_f t_{off}* ns max	Test Circuit Fig. No.
NPN						
MMCS2192	20	–	2.0 50 10 20	–,85	180,60	1
MMCS2193	20	–	2.0 50 10 20	–,85	180,60	1
MMCS2221	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS2221A	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS2222	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS2222A	8.0	30	2.5 20 20 100	26*(1)	70*(1)	2
MMCS3498 ①	10	80	1.5 20 20 100	20,35	300,80	–
MMCS3499 ①	10	80	1.5 20 20 100	20,35	300,80	–
MMCS3500 ①	8.0	80	1.5 20 20 100	20,35	300,80	–
MMCS3501 ①	8.0	80	1.5 20 20 100	20,35	300,80	–
MMCS3903	4.0	8.0	2.0 10 20 100	40,40	200,60	6
MMCS3904	4.0	8.0	2.5 10 20 100	40,40	240,60	6
MMCS4400	6.5*	30*	1.8 20 10 100	18,25	260,35	8
MMCS4401	6.5*	30*	2.3 20 10 100	18,25	260,35	8
PNP						
MMCS2906	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS2906A	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS2907	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS2907A	8.0	30	2.0 50 20 100	26*(1)	70*(1)	3
MMCS3250	6.0	8.0	2.3 10 20 100	40,40	200,60	4
MMCS3250A	6.0	8.0	2.3 10 20 100	40,40	200,60	4
MMCS3251	6.0	8.0	2.8 10 20 100	40,40	240,60	4
MMCS3251A	6.0	8.0	2.8 10 20 100	40,40	240,60	4
MMCS3634 ①	10	75	1.2 30 30 100	480*	720*	5
MMCS3635 ①	10	75	1.6 30 30 100	480*	720*	5
MMCS3636 ①	10	75	1.2 30 30 100	480*	720*	5
MMCS3637 ①	10	75	1.6 30 30 100	480*	720*	5
MMCS3905	4.5	10	1.6 10 20 100	40,40	240,70	7
MMCS3906	4.5	10	2.0 10 20 100	40,40	250,85	7
MMCS4402	8.5*	30*	1.3 20 10 100	18,25	260,35	9
MMCS4403	8.5*	30*	1.8 20 10 100	18,25	260,35	9

① SMALL-SIGNAL CHARACTERISTICS

(I_C = 10 mA, V_{CE} = 10 V, f = 1.0 kHz)

TYPE	h_{ie} k ohms min/max	h_{re} x 10^{-4} max	h_{oe} µmhos min/max
NPN			
MMCS3498	0.16/1.2	3.0	8.0/120
MMCS3499	0.2/1.5	4.8	16/240
MMCS3500	0.16/1.2	3.0	8.0/120
MMCS3501	0.2/1.5	4.8	16/240
PNP			
MMCS3634	80/720	3.6	–/240
MMCS3635	165/1400	3.6	–/240
MMCS3636	80/720	3.6	–/240
MMCS3637	165/1400	3.6	–/240

*AC parameter values are as specified in the standard 2N data sheets. (encapsulated devices)

(1) Typical Switching Times

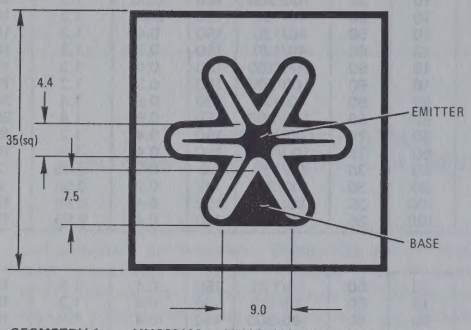
PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual Inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

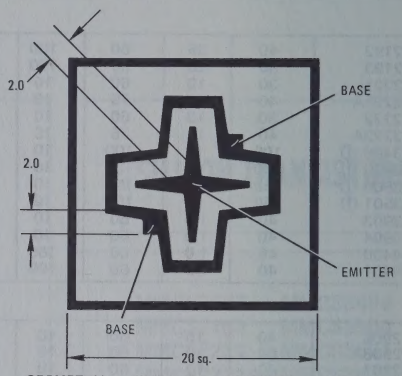
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

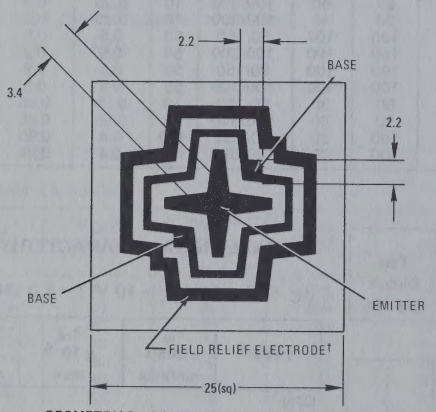
ALL DIMENSIONS ARE IN MILS



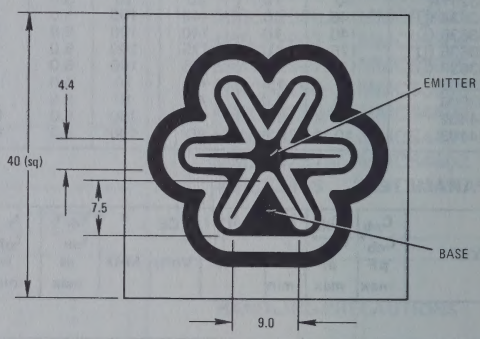
GEOMETRY 1 MMCS2192 MMCS3498 MMCS3500 NPN
MMCS2193 MMCS3499 MMCS3501



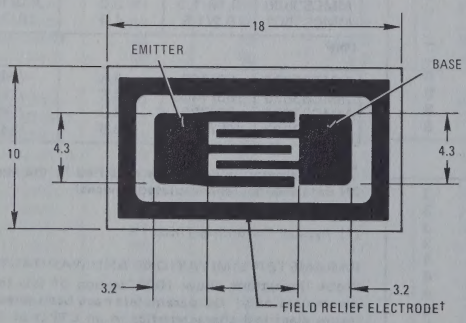
GEOMETRY 2 MMCS2221 MMCS2222 NPN
MMCS2221A MMCS2222A



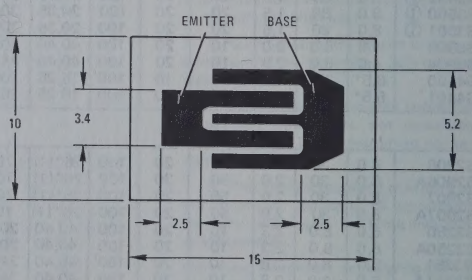
GEOMETRY 3 MMCS2906 MMCS2907 PNP
MMCS2906A MMCS2907A



GEOMETRY 4 MMCS3634 MMCS3636 PNP
MMCS3635 MMCS3637



GEOMETRY 5 MMCS3250 MMCS3251A PNP
MMCS3250A MMCS3905
MMCS3251 MMCS3906



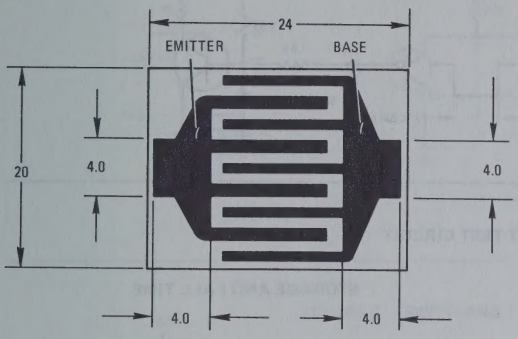
GEOMETRY 6 MMCS3903 MMCS3904 NPN

†Patented by Motorola – Patent No. 3, 302, 076.

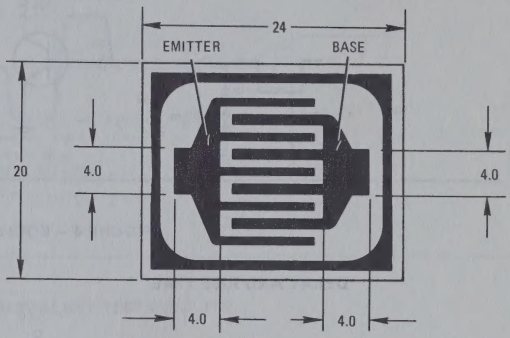
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



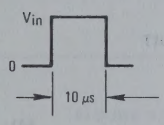
GEOMETRY 7 MMCS4400 MMCS4401 NPN



GEOMETRY 8 MMCS4402 MMCS4403 PNP

TEST CIRCUITS

FIGURE 1 – SWITCHING TIME TEST CIRCUIT



t_r = 20 ns
t_f = 20 ns
R_{gen} = 50

MMCS2192 – V_{in} = 7.5 V, V_b = 7.5 V
MMCS2193 – V_{in} = 15 V, V_b = 15 V

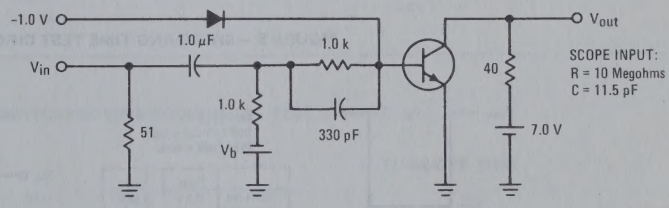
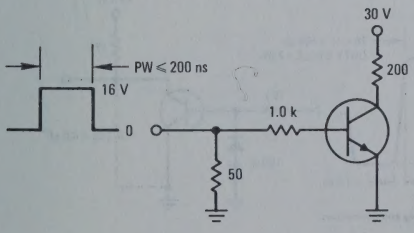


FIGURE 2 – SWITCHING TIME TEST CIRCUIT

TURN-ON TIME



TURN-OFF TIME

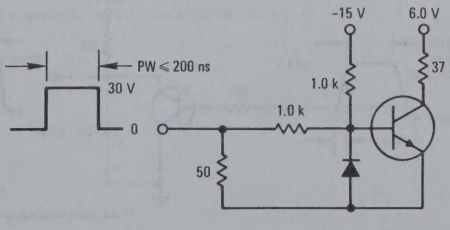


FIGURE 3 – SATURATED SWITCHING TIME TEST CIRCUIT

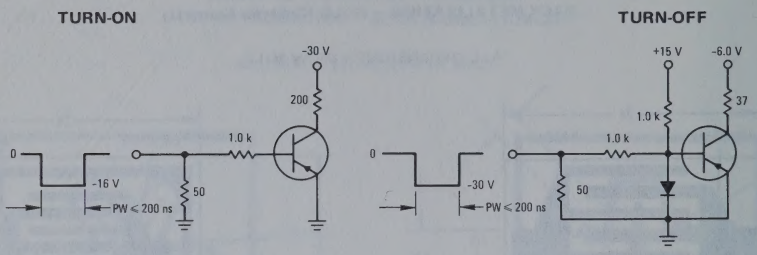


FIGURE 4 – EQUIVALENT TEST CIRCUIT

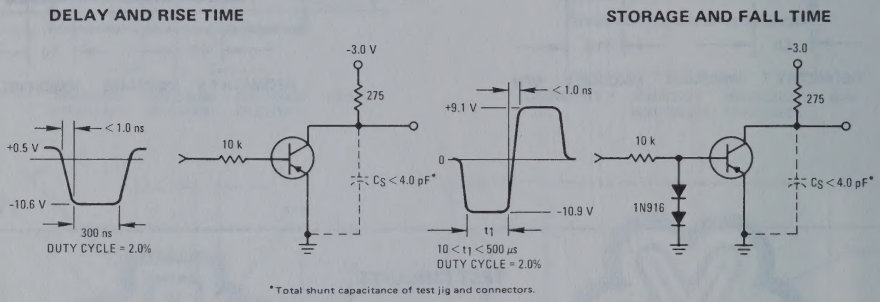
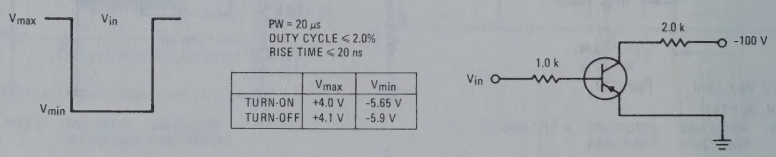


FIGURE 5 – SWITCHING TIME TEST CIRCUIT



	V_{max}	V_{min}
TURN-ON	+4.0 V	-5.65 V
TURN-OFF	+4.1 V	-5.9 V

FIGURE 6 – EQUIVALENT TEST CIRCUIT

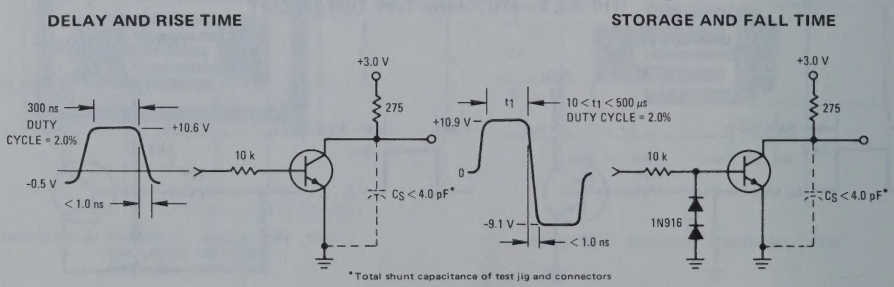
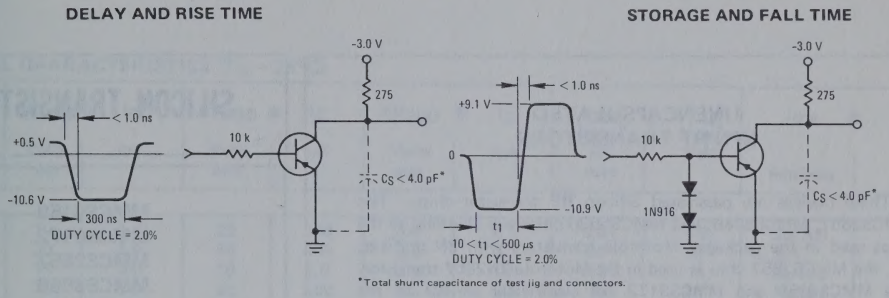
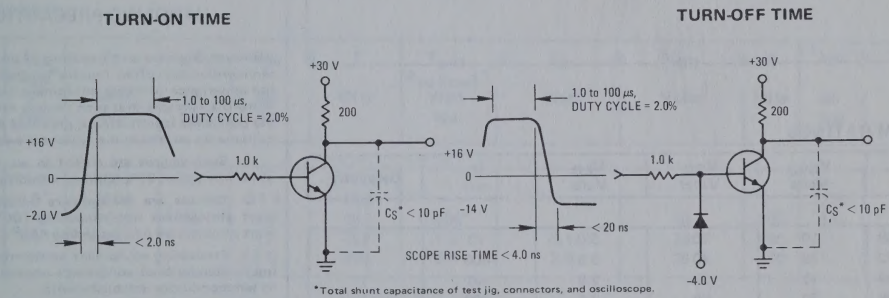


FIGURE 7 – EQUIVALENT TEST CIRCUIT



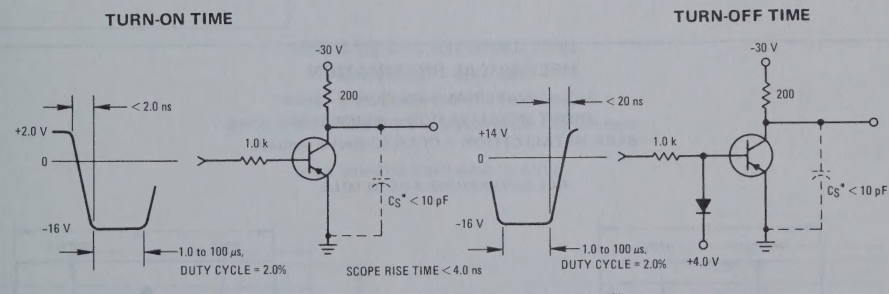
*Total shunt capacitance of test jig and connectors.

FIGURE 8 – SWITCHING TIME EQUIVALENT TEST CIRCUITS



*Total shunt capacitance of test jig, connectors, and oscilloscope.

FIGURE 9 – SWITCHING TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig, connectors, and oscilloscope

UNENCAPSULATED NPN RF TRANSISTORS

These devices are passivated Silicon RF transistor chips. The MMCS2857, MMCS3866, and MMCS5636 chips are identical to the chips used in the packaged Motorola transistors with 2N prefixes; i.e., the MMCS2857 chip is used in the Motorola 2N2857 transistor. The MMCS0159 and MMCS0172 are electrically similar to the MM1605, MM1606, MM1607 series and MM8002 respectively.

- Power Outputs to 8.4 Watts Typical at 400 MHz
- f_T to 2000 MHz Typical

SILICON TRANSISTORS

MMCS0159
MMCS0172
MMCS2857
MMCS3866
MMCS5636

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in a non-inert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

MAXIMUM RATINGS

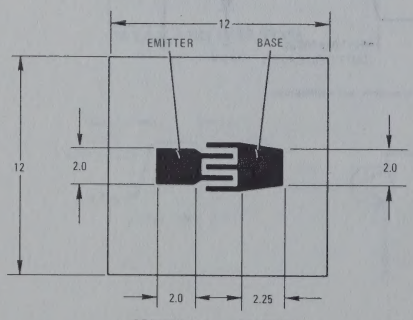
TYPE	V_{CEO} Volts	V_{CB} Volts	V_{EB} Volts	I_C mA	Geometry
NPN					
MMCS0159	10	20	3.0	70	1
MMCS0172	30	40	3.5	400	2
MMCS2857	15	30	2.5	40	3
MMCS3866	30	55	3.5	400	2
MMCS5636	35	60	4.0	400	4

Operating and Storage Junction Temperature Range −65 to +200°C

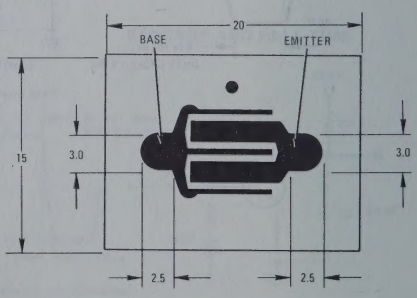
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 1 MMCS0159



GEOMETRY 2 MMCS0172 MMCS3866

NPN RF TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	BV_{CEO} @ I_C		BV_{CBO} @ I_C		BV_{EBO} @ I_E		I_{CBO} @ V_{CB} I_{CEO}* V_{CE}*		h_{FE} @ I_C	
	Volts min	mA	Volts min	μA	Volts min	mA	μA max	Volts	min/max	mA
NPN										
MMCS0159	10	1.0	20	100	3.0	0.1	0.01	4.0	25/200	25
MMCS0172	30	5.0	40	100	3.5	0.1	20*	28*	30/–	50
MMCS2857	15	3.0	30	1.0	2.5	0.01	0.01	15	30/150	3.0
MMCS3866	30	5.0	55	100	3.5	0.1	20*	28*	10/200	50
MMCS5636	35	200	50	100	4.0	5.0	1000	30	5.0/–	200

AC* PARAMETERS

TYPE	C_{cb} C_{ob}*	f_T	$r_b'C_c$	G_{pe} @ f		P_{out} @ $P_{out(osc)}$*	P_{in} &	V_{CE} & f		NF @ f	
	pF max	MHz typ	ps typ	dB typ	MHz	Watt typ	Watt	Volts	MHz	dB typ	MHz
NPN											
MMCS0159	1.0	2000	15	–	–	–	–	–	–	–	–
MMCS0172	3.5*	1500	–	11.4	200	–	–	–	–	2.7	200
MMCS2857	1.0	1500	15	15	450	0.035*	–	10	500	4.0	450
MMCS3866	3.0*	800	–	11	400	1.3	0.1	28	400	–	–
MMCS5636	20	–	–	7.0	400	8.4	2.0	28	400	–	–

*AC parameter values are as specified in the standard 2N or MM data sheets. (encapsulated devices)

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

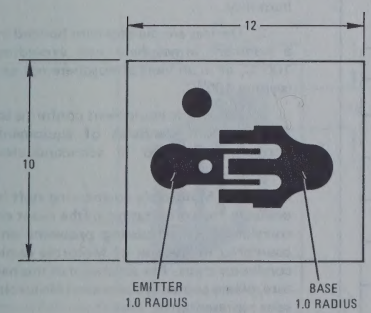
MECHANICAL INFORMATION

MATERIAL – SILICON

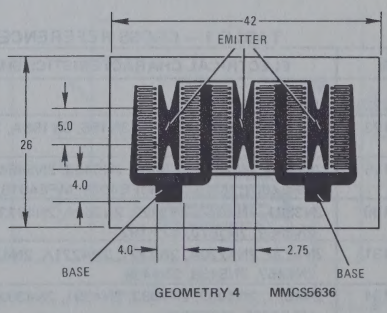
FRONT METALIZATION – ALUMINUM

BACK METALIZATION – GOLD (Collector Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 3 MMCS2857



GEOMETRY 4 MMCS5636

UNENCAPSULATED FIELD-EFFECT TRANSISTORS

These devices are passivated Field-Effect transistor chips electrically similar to those listed in Table 1. For more detailed characteristic data, please refer to the appropriate Motorola data sheet.

- MOS FETs are Silicon Nitride Passivated
- MOS and Junction Types
- P-Channel and N-Channel

SILICON TRANSISTORS

MMCS0122
MMCS0123
MMCS0125
MMCS0130
MMCS0131
MMCS0134

MAXIMUM RATINGS

MOS FETS

TYPE	V_{DS} Volts	V_{DG} Volts	V_{GS} Volts	I_D mA	Geometry	Application
N-Channel						
MMCS0122	25	±30	±30	30	1	Low Power Switch
P-Channel						
MMCS0123	25	±30	±30	30	1	Low Power Switch

JUNCTION FETS

TYPE	V_{DS} Volts	V_{DG} Volts	$V_{GS(r)}$ Volts	$I_{G(f)}$ mA	I_D mA	Geometry	Application
N-Channel							
MMCS0130	25	25	-25	10	20	2	VHF Amplifier and Mixer
MMCS0131	25	25	-25	10	20	3	General-Purpose Audio and Switching
MMCS0134	30	30	-30	10	–	4	Chopper
P-Channel							
MMCS0125	40	40	40	10	20	2	General-Purpose Amplifier

Operating and Storage Junction Temperature Range -65 to +200°C

TABLE 1 – CROSS REFERENCE CHART

DEVICE	ELECTRICAL CHARACTERISTICS SIMILAR TO:
MMCS0122	2N4351
MMCS0123	2N4352, 3N155, 3N155A, 3N156, 3N156A, 3N157, 3N157A, 3N158, 3N158A
MMCS0125	2N5460, 2N5461, 2N5462, 2N5463, 2N5464, 2N5465, MPF161, MFE4007, MFE4008, MFE4009, MFE4010, MFE4011, MFE4012
MMCS0130	2N3821, 2N3822, 2N3823, 2N3824, 2N4223, 2N4224, 2N5668, 2N5669, 2N5670, MPF102
MMCS0131	2N4220, 2N4220A, 2N4221, 2N4221A, 2N4222, 2N4222A, 2N5457, 2N5458, 2N5459
MMCS0134	2N4091, 2N4092, 2N4093, 2N4391, 2N4392, 2N4393, MFE2004, MFE2005, MFE2006

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

FIELD-EFFECT TRANSISTORS (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

MOS FETS

TYPE	$V_{GS(th)}$ Volts min/max	$V_{DS(on)}$ Volts max	$I_{D(on)}$ mA min	$V_{BR(DSS)}$ Volts min	I_{GSS} pA typ	I_{DSS} nA max	$r_{ds(on)}$ Ohms max	$\|y_{fs}\|$ µmhos min	C_{iss} pF max	C_{rss} pF max	$C_{d(sub)}$ pF max	t_d, t_r ns max	t_s, t_f ns max
N-Channel													
MMCS0122	1.0/5.0	1.0	3.0	25	0.10	10	300	1000	5.0	1.3	5.0	45,65	60,100
P-Channel													
MMCS0123	-1.0/-5.0	-1.0	-3.0	-25	0.10	-10	600	1000	5.0	1.3	4.0	45,65	60,100

JUNCTION FETS

TYPE	$V_{BR(GSS)}$ Volts min	$V_{GS(off)}$ Volts min/max	I_{GSS} nA max	I_{DSS} mA min/max	V_{GS} Volts min/max	$\|y_{fs}\|$ µmhos typ/max	$\|y_{os}\|$ µmhos max	C_{iss} pF max	C_{rss} pF max	$r_{DS(on)}$ Ohms max
N-Channel										
MMCS0130	-25	0.2/8.0	-5.0	2.0/20	0.5/7.5	3000/7000	75	7.0	3.0	–
MMCS0131	-25	0.5/8.0	-5.0	1.0/16	0.5/7.5	1000/6000	50	7.0	3.0	–
MMCS0134	30	1.0/12	5.0	8.0/–	1.0/10	–	–	16	5.0	100
P-Channel										
MMCS0125	40	0.2/8.0	5.0	0.5/14	0.5/7.5	2500/6000	75	7.0	2.0	–

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20. Visual inspection is performed to an LTPD of 20. See "Visual Inspection Criteria" in General Information Section.

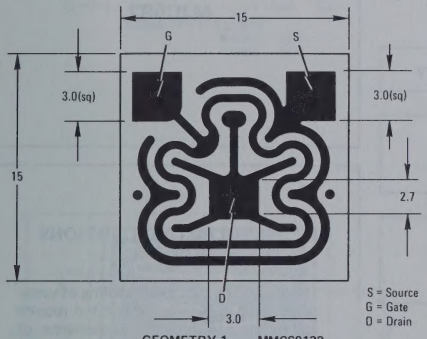
MECHANICAL INFORMATION

MATERIAL – SILICON

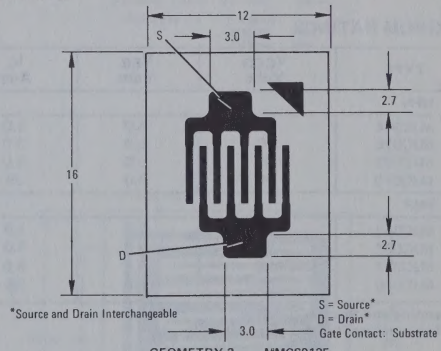
FRONT METALIZATION – ALUMINUM

BACK METALIZATION – GOLD (Substrate)

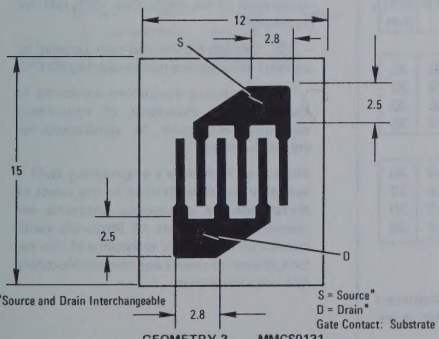
ALL DIMENSIONS ARE IN MILS



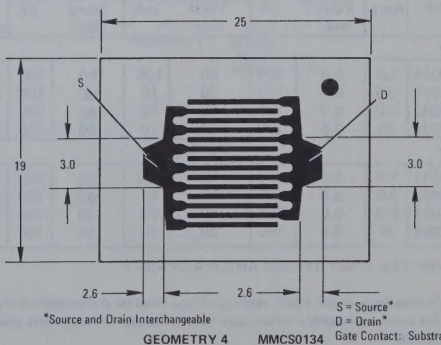
GEOMETRY 1 MMCS0122 MMCS0123



GEOMETRY 2 MMCS0125 MMCS0130



GEOMETRY 3 MMCS0131



GEOMETRY 4 MMCS0134

SILICON TRANSISTORS

UNENCAPSULATED SILICON POWER TRANSISTORS

These devices are passivated Silicon power transistor chips suitable for collector currents to 25 amperes. Both NPN and PNP devices are available for maximum versatility and may be used in complementary circuitry.

- Collector Currents to 25 Amperes
- Breakdown Voltage to 60 Volts
- DC Current Gains to 30 Volts Minimum
- High f_T (30 MHz Minimum)

MJC007
MJC043
MJC044
MJC067
MJC069
MJC070
MJC076
MJC082

MAXIMUM RATINGS

TYPE	V_{CEO} Volts	V_{EB} Volts	I_C Amp	Geometry
NPN				
MJC044	60	5.0	1.0	2
MJC076	50	5.0	3.0	1
MJC082	60	5.0	5.0	3
MJC070	60	5.0	25	4
PNP				
MJC043	60	5.0	1.0	2
MJC007	50	5.0	3.0	1
MJC067	60	5.0	5.0	3
MJC069	60	5.0	25	4

Operating and Storage Junction Temperature Range −65 to +200°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	I_C Amp	BV_{EBO} @ I_E Volts min	μA	BV_{CEO} @ I_C Volts min	mA	BV_{CES} @ I_C Volts min	μA	h_{FE} @ I_C, V_{CE} min/max	Amp	Volts	f_T MHz min
NPN											
MJC044	1.0	5.0	500	60	100	60	100	30/180	0.250	1.0	30
MJC076	3.0	5.0	100	50	10	50	100	20/180	1.0	2.0	30
MJC082	5.0	5.0	100	60	10	60	100	30/180	2.0	2.0	30
MJC070	25	5.0	100	60	10	60	100	20/180	10	3.0	30
PNP											
MJC043	1.0	5.0	500	60	100	60	100	30/180	0.250	1.0	30
MJC007	3.0	5.0	100	50	10	50	100	20/180	1.0	2.0	30
MJC067	5.0	5.0	100	60	10	60	100	30/180	2.0	2.0	30
MJC069	25	5.0	100	60	10	60	100	20/180	10	3.0	30

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. Limits for all parameters listed for power transistor chips have been selected to insure the electrical characteristics to an LTPD of 20.

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

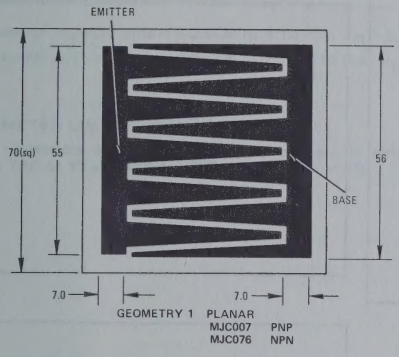
1. Such devices are stored in an environment of no more than 30% relative humidity.
2. Devices are die-and-wire bonded in an inert atmosphere not exceeding 400°C.
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

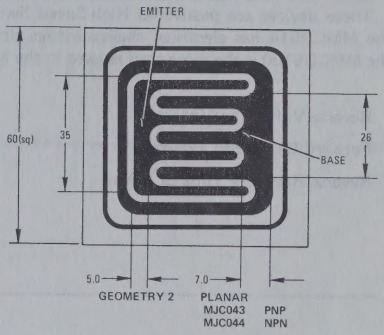
MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Collector Contact)

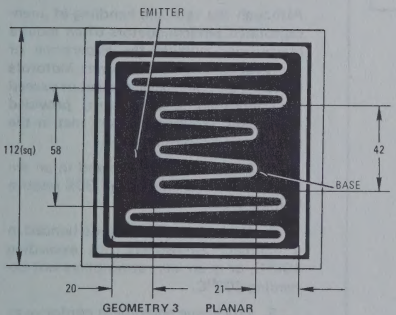
ALL DIMENSIONS ARE IN MILS



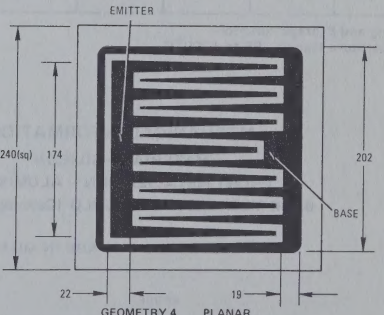
GEOMETRY 1 PLANAR
MJC007 PNP
MJC076 NPN



GEOMETRY 2 PLANAR
MJC043 PNP
MJC044 NPN



GEOMETRY 3 PLANAR
MJC067 PNP
MJC082 NPN



GEOMETRY 4 PLANAR
MJC069 PNP
MJC070 NPN

UNENCAPSULATED
HIGH-SPEED SWITCHING DIODES

These devices are passivated High-Speed Switching diode chips. The MMCD914 has electrical characteristics similar to the 1N914. The MMCD6100 is the same chip as used in the Motorola MSD6100.

- Reverse Voltage to 100 Volts
- Forward Current to 225 mA
- Reverse Recovery Time of 4.0 ns

SILICON SWITCHING DIODES

MMCD914

MMCD6100

MAXIMUM RATINGS

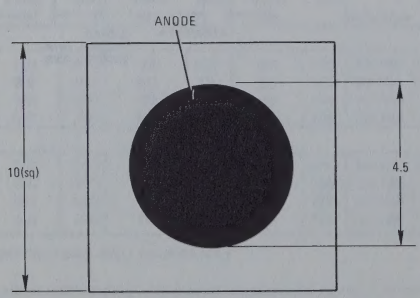
TYPE	V_R Volts	I_O mA	I_F mA	$I_{F(surge)}$ mA	T_J, T_{stg} °C	Geometry
MMCD914	75	75	225	500	-65 to +150	1
MMCD6100	100	–	200	500	-55 to +135	1

Operating and Storage Junction Temperature Range -65 to +200°C

MECHANICAL INFORMATION

MATERIAL – SILICON
FRONT METALIZATION – ALUMINUM
BACK METALIZATION – GOLD (Cathode Contact)

ALL DIMENSIONS ARE IN MILS



GEOMETRY 1 MMCD914 MMCD6100

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in a noninert atmosphere not exceeding 100°C, or in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

HIGH-SPEED SWITCHING DIODES (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C)

TYPE	$V_{(BR)}$ @ $I_{(BR)}$ = 100 μA Volts min	I_R @ V_R μA max	I_R @ V_R Volts	I_R @ V_R nA max	I_R @ V_R Volts	V_F @ I_F = 10 mA min/max	C @ V_R = 0 pF max
MMCD914 ①	100	5.0	75	25	20	–/1.0	4.0
MMCD6100 ②	100	5.0	100	100	50	0.65/0.85	1.5

① Reverse recovery time = 5.0 ns @ I_F = 10 mA, V_R = 6.0 V, i_{rr} = 1.0 mA

② Reverse recovery time = 5.0 ns @ I_F = I_R = 10 mA, V_R = 5.0 V, i_{rr} = 1.0 mA

PARAMETER LIMITATIONS AND WARRANTY

Probe limitations allow 100% testing of low level dc parameters only. DC parameters have been selected to insure electrical characteristics to an LTPD of 10 and ac parameters to an LTPD of 20.

MOTOROLA SPECIAL MICROCIRCUIT ZENER DIODE SELECTION

I Special Microcircuit Component Selection

Most standard zener diode devices are available in chip form to meet a wide variety of application requirements. Nonstandard chips are available on a negotiated basis. Special zero-temperature-compensated zener diode chips are also available upon request. Contact your local Motorola representative for more information.

II General Features

1. The MZC2.4A10 and MZC1.8B10 series have gold-backed metalization. All other chips have a chrome-silver-gold backing.
2. All zener diode chips have silicon-oxide-passivated junctions.
3. Zener chips are available in 10% (standard), 5%, 3%, 2% and 1% tolerances.
4. Most standard zener diode and current regulator chips are available.

III Electrical Parameter Test Capability

The following parameters may be tested on a 100% basis:

Zener Diodes	Current Regulators
1. V_Z	1. I_p
2. I_R	2. Z_T
3. Z_{ZT}	3. Z_K
4. Z_{ZK}	4. V_L
5. V_f	

IV Policies

1. Devices shipped in Deka-Pak and Multi-Pak containers are equipped with a tamper-proof seal. No returns will be accepted once the "tamper-proof" seal has been broken, due to the possibility of mechanical damage.
2. Devices shipped in other than preferred packages (see "Packaging" section) require special negotiation to prevent negation of warranty.

V Order Quantity Requirements

1. Zener diode chips must be ordered in multiples of 10 to facilitate packaging and warehousing requirements.
2. All orders must state type of packaging required (see packaging section).

VI Mounting and Handling

1. General

   (A) Both chip mounting and lead bonding should be carried out in a carefully controlled atmosphere for best results. Vacuum probes should be used for handling the chips. Handling should be minimized, and a cleaning operation must be performed as soon as possible prior to mounting. Also, extreme care should be taken when probing electrically to avoid scratching or cracking the chip.

   The mounting pads must be large enough to permit "scrubbing", and lead bonds must be "looped" from the chip to substrate to eliminate possible shorting.

2. Gold-Backed Chips (MZC Series)

   (A) For chip mounting, a gold-silicon eutectic bond is normally used. Electrically conductive epoxies may also be used. Since fluxes are not used, the chip must be "scrubbed", either manually or ultrasonically, on a preheated mounting surface to get a reliable ohmic chip contact. Use of a solder preform during mounting minimizes the chip-mount thermal resistance; the preform usually is gold or gold-doped with arsenic or

antimony. Power dissipation is dependent on the quality of the chip mount. Lead bonding is normally accomplished either by ultrasonic or thermal compression techniques using gold or aluminum wire.

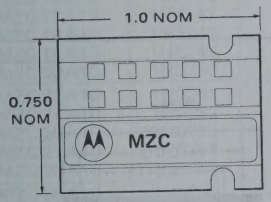
3. Chrome-Silver-Gold-Backed Chips (Conventional Series)

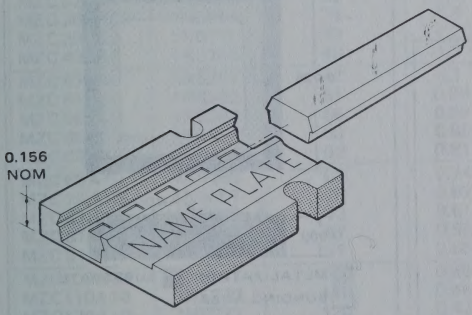
(A) The chrome-silver-gold-backed chips used for conventional packaged zeners cannot be eutectically bonded. We would recommend a solder bond, but electrically conductive epoxies may be used. Motorola uses a gold-germanium solder (12.5% germanium, 1% indium, balance gold); however, the customer may have others which work as well or better. Information specified for the MZC series also applies.

VII Packaging

1. The following types of packaging are available:

(A) **Deka-Pak (10-chip carrier)** – Preferred for orders of 30 or less:

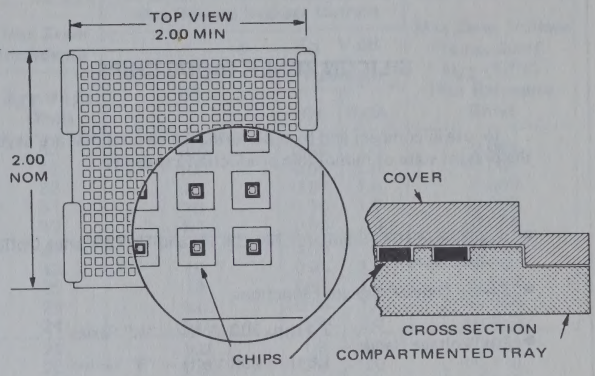




Standard Chip Carrier Package

To accommodate the customer with limited quantity requirements, the 10-chip carrier contains individual compartments for the chips and affords ease of inventory for the user. The carrier protects the chips during storage and handling and permits visual inspection without removing the chips.

(B) **Multi-Pak (400-chip carrier) – Preferred** for orders of 40 or more:



The Multi-Pak carrier is designed with an individual compartment for each chip.

Features of this carrier include:

(a) visual inspection without removal from carrier.

(b) carrier usable in customer production area.

(c) storage container for unused chips.

(C) **Straw-Pak (1500 chip maximum)** Non-Preferred:

The Straw-Pak is a vial encompassing a straw that has one end closed. The zener chips are inserted in the straw, and then the straw is bent and placed in the plastic vial for shipment.

2. The carrier package options are available for 37-mil square or smaller chips (500 mW or less on a conventional series). Packaging of larger geometry chips must be negotiated.

3. Chips will be placed randomly in their carriers with either side up for visual inspection requirements.

4. All packages are shipped with "tamper-proof" seals to insure that only qualified personnel will handle chips and to insure proper protection during transit.

SILICON ZENER DIODE CHIPS

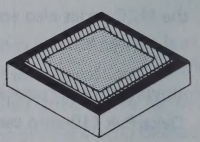
. . . for use in compact and high performance circuits that are beyond the present state of monolithic production capability.

- Available in 10% (Standard), 5%, 3%, 2% and 1% Tolerance Options (See Note 1)
- Silicon Oxide Passivated Junctions
- Full Voltage Range — 2.4 thru 200 Volts — "A" Series; 1.8 thru 200 Volts — "B" Series
- Limits Guaranteed on Four Electrical Parameters
- Both Anode and Cathode Chip Metalization Compatible with all Wire and Die Bonding Techniques

SILICON ZENER DIODES

MZC2.4A10 thru MZC200A10
HIGH LEVEL SERIES

MZC1.8B10 thru MZC200B10
LOW LEVEL SERIES



CHIP (MZC)

MAXIMUM RATINGS

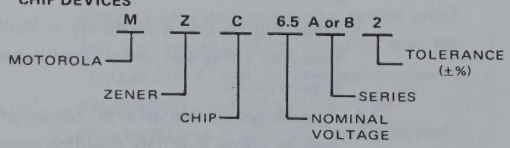
Rating	Symbol	Value	Unit
DC Power Dissipation @ $T_A = 50^oC$ Derate 3.2 mW/^oC above 50^oC	P_D	400	mW
When Mounted on a 1.0" x 1.0" x 0.010" Aluminum Plate			
Junction and Storage Temperature Range	T_J, T_{stg}	−65 to +175	^oC

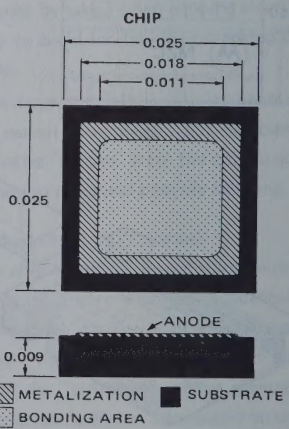
NOTE 1 — TOLERANCE AND VOLTAGE DESIGNATION

Tolerance Designation — The device type numbers listed have a tolerance of ±10%. For a ±5%, 3%, 2%, or 1%, change the suffix "10" to the desired tolerance.

Voltage Designation — To order devices with Zener voltages other than those listed, the Motorola type number should be modified as shown below.

CHIP DEVICES





MZC SERIES — This is a series of gold-backed silicon oxide passivated chips. Chips are compatible with all standard die bonding techniques used in hybrid circuits

DIMENSIONS: NOMINAL

MZC

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)
V_F = 1.5 V Max @ I_F = 200 mA for all types.

Type Number (Note 1)	Nearest 1N Equivalent	Nominal Zener Voltage V_Z @ I_{ZT} Volts (Note 1)	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Reverse Leakage Current @ I_R µA	Max Reverse Leakage Current @ V_R Volts Tolerance 10%	Max Reverse Leakage Current @ V_R Volts Tolerance 5.0%	Max Zener Voltage Temp. Coeff. θV_Z (%/°C) (For Reference Only)
MZC2.4A10	1N5221	2.4	21	53	100	0.95	1.0	-0.085
MZC2.5A10	1N5222	2.5	20	53	100	0.95	1.0	-0.085
MZC2.7A10	1N5223	2.7	19	52	75	0.95	1.0	-0.080
MZC2.8A10	1N5224	2.8	18	51	75	0.95	1.0	-0.080
MZC3.0A10	1N5225	3.0	17	50	50	0.95	1.0	-0.075
MZC3.3A10	1N5226	3.3	15	47	25	0.95	1.0	-0.070
MZC3.6A10	1N5227	3.6	14	43	15	0.95	1.0	-0.065
MZC3.9A10	1N5228	3.9	13	35	10	0.95	1.0	-0.060
MZC4.3A10	1N5229	4.3	12	29	5.0	0.95	1.0	±0.055
MZC4.7A10	1N5230	4.7	11	24	5.0	1.9	2.0	±0.030
MZC5.1A10	1N5231	5.1	9.8	21	5.0	1.9	2.0	±0.030
MZC5.6A10	1N5232	5.6	8.9	25	5.0	2.9	3.0	+0.038
MZC6.0A10	1N5233	6.0	8.3	30	5.0	3.3	3.5	+0.038
MZC6.2A10	1N5234	6.2	8.1	31	5.0	3.8	4.0	+0.045
MZC6.8A10	1N5235	6.8	7.3	38	3.0	4.8	5.0	+0.050
MZC7.5A10	1N5236	7.5	6.7	43	3.0	5.7	6.0	+0.058
MZC8.2A10	1N5237	8.2	6.1	49	3.0	6.2	6.5	+0.062
MZC8.7A10	1N5238	8.7	5.7	52	3.0	6.2	6.5	+0.065
MZC9.1A10	1N5239	9.1	5.5	54	3.0	6.7	7.0	+0.068
MZC10A10	1N5240	10	5.0	60	3.0	7.6	8.0	+0.075
MZC11A10	1N5241	11	4.5	66	2.0	8.0	8.4	+0.076
MZC12A10	1N5242	12	4.2	71	1.0	8.7	9.1	+0.077
MZC13A10	1N5243	13	3.8	74	0.5	9.4	9.9	+0.079
MZC14A10	1N5244	14	3.6	33	0.1	9.5	10	+0.082
MZC15A10	1N5245	15	3.3	37	0.1	10.5	11	+0.082
MZC16A10	1N5246	16	3.1	42	0.1	11.4	12	+0.083
MZC17A10	1N5247	17	2.9	47	0.1	12.4	13	+0.084
MZC18A10	1N5248	18	2.8	52	0.1	13.3	14	+0.085
MZC19A10	1N5249	19	2.6	58	0.1	13.3	14	+0.086
MZC20A10	1N5250	20	2.5	65	0.1	14.3	15	+0.086
MZC22A10	1N5251	22	2.3	70	0.1	16.2	17	+0.087
MZC24A10	1N5252	24	2.1	92	0.1	17.1	18	+0.088
MZC25A10	1N5253	25	2.0	100	0.1	18.1	19	+0.089
MZC27A10	1N5254	27	1.9	115	0.1	20	21	+0.090
MZC28A10	1N5255	28	1.8	120	0.1	20	21	+0.091
MZC30A10	1N5256	30	1.7	140	0.1	22	23	+0.091
MZC33A10	1N5257	33	1.5	170	0.1	24	25	+0.092
MZC36A10	1N5258	36	1.4	200	0.1	26	27	+0.093
MZC39A10	1N5259	39	1.3	230	0.1	29	30	+0.094
MZC43A10	1N5260	43	1.2	280	0.1	31	33	+0.095
MZC47A10	1N5261	47	1.1	330	0.1	34	36	+0.095
MZC51A10	1N5262	51	0.98	390	0.1	37	39	+0.096
MZC56A10	1N5263	56	0.89	460	0.1	41	43	+0.096
MZC60A10	1N5264	60	0.83	530	0.1	44	46	+0.097
MZC62A10	1N5265	62	0.81	560	0.1	45	47	+0.097
MZC68A10	1N5266	68	0.74	680	0.1	49	52	+0.097
MZC75A10	1N5267	75	0.67	800	0.1	53	56	+0.098
MZC82A10	1N5268	82	0.61	980	0.1	59	62	+0.098
MZC87A10	1N5269	87	0.57	1050	0.1	65	68	+0.099
MZC91A10	1N5270	91	0.55	1150	0.1	66	69	+0.099
MZC100A10	1N5271	100	0.50	1400	0.1	72	76	+0.110
MZC110A10	1N5272	110	0.45	1700	0.1	80	84	+0.110
MZC120A10	1N5273	120	0.42	2000	0.1	86	91	+0.110
MZC130A10	1N5274	130	0.38	2300	0.1	94	99	+0.110
MZC140A10	1N5275	140	0.36	2700	0.1	101	106	+0.110
MZC150A10	1N5276	150	0.33	3000	0.1	108	114	+0.110
MZC160A10	1N5277	160	0.31	3400	0.1	116	122	+0.110
MZC170A10	1N5278	170	0.29	3900	0.1	123	129	+0.110
MZC180A10	1N5279	180	0.28	4300	0.1	130	137	+0.110
MZC190A10	1N5280	190	0.26	4800	0.1	137	144	+0.110
MZC200A10	1N5281	200	0.25	5200	0.1	144	152	+0.110

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)
V_F = 1.5 V Max @ I_F = 200 mA for all types.

Type Number (Note 1)	Nearest 1N Equivalent	Nominal Zener Voltage V_Z @ I_{ZT} = 250 μA Volts (Note 1)	Max Zener Impedance Z_{ZT} @ I_{ZT} = 250 μA Ohms	Max Reverse Leakage Current I_R μA @ V_R Volts		
					Tolerance	
					10%	5.0%
MZC1.8B10	1N4614	1.8	1200	7.5	0.9	1.0
MZC2.0B10	1N4615	2.0	1250	5.0	0.9	1.0
MZC2.2B10	1N4616	2.2	1300	4.0	0.9	1.0
MZC2.4B10	1N4617	2.4	1400	2.0	0.9	1.0
MZC2.7B10	1N4618	2.7	1500	1.0	0.9	1.0
MZC3.0B10	1N4619	3.0	1600	0.8	0.9	1.0
MZC3.3B10	1N4620	3.3	1650	7.5	1.0	1.5
MZC3.6B10	1N4621	3.6	1700	7.5	1.5	2.0
MZC3.9B10	1N4622	3.9	1650	5.0	1.5	2.0
MZC4.3B10	1N4623	4.3	1600	4.0	1.5	2.0
MZC4.7B10	1N4624	4.7	1550	10	2.5	3.0
MZC5.1B10	1N4625	5.1	1500	10	2.5	3.0
MZC5.6B10	1N4626	5.6	1400	10	3.5	4.0
MZC6.2B10	1N4627	6.2	1200	10	4.5	5.0
MZC6.8B10	1N4099	6.8	200	10	4.8	5.2
MZC7.5B10	1N4100	7.5	200	10	5.5	5.7
MZC8.2B10	1N4101	8.2	200	1.0	6.0	6.3
MZC8.7B10	1N4102	8.7	200	1.0	6.2	6.6
MZC9.1B10	1N4103	9.1	300	1.0	6.7	6.9
MZC10B10	1N4104	10	400	1.0	7.0	7.6
MZC11B10	1N4105	11	400	0.05	8.0	8.5
MZC12B10	1N4106	12	300	0.05	8.7	9.1
MZC13B10	1N4107	13	200	0.05	9.4	9.9
MZC14B10	1N4108	14	200	0.05	9.5	10.7
MZC15B10	1N4109	15	200	0.05	10.5	11.4
MZC16B10	1N4110	16	200	0.05	11.4	12.2
MZC17B10	1N4111	17	200	0.05	12.4	12.9
MZC18B10	1N4112	18	200	0.05	13.3	13.7
MZC19B10	1N4113	19	200	0.05	13.3	14.5
MZC20B10	1N4114	20	200	0.01	14.3	15.2
MZC22B10	1N4115	22	200	0.01	16.2	16.7
MZC24B10	1N4116	24	200	0.01	17.1	18.5
MZC25B10	1N4117	25	200	0.01	18.1	19.0
MZC27B10	1N4118	27	200	0.01	20	20.5
MZC28B10	1N4119	28	200	0.01	20	21.3
MZC30B10	1N4120	30	200	0.01	22	22.6
MZC33B10	1N4121	33	200	0.01	24	25.1
MZC36B10	1N4122	36	200	0.01	26	27.4
MZC39B10	1N4123	39	200	0.01	29	29.7
MZC43B10	1N4124	43	250	0.01	31	32.7
MZC47B10	1N4125	47	250	0.01	34	35.8
MZC51B10	1N4126	51	300	0.01	37	38.8
MZC56B10	1N4127	56	300	0.01	41	42.6
MZC60B10	1N4128	60	300	0.01	44	45.6
MZC62B10	1N4129	62	300	0.01	45	47.1
MZC68B10	1N4130	68	400	0.01	49	51.7
MZC75B10	1N4131	75	500	0.01	53	57.0
MZC82B10	1N4132	82	600	0.01	59	62.3
MZC87B10	1N4133	87	700	0.01	65	66.1
MZC91B10	1N4134	91	800	0.01	66	69.2
MZC100B10	1N4135	100	1000	0.01	72	76.0
MZC110B10	–	110	1300	0.01	80	84.0
MZC120B10	–	120	1600	0.01	86	91.0
MZC130B10	–	130	1900	0.01	94	99.0
MZC140B10	–	140	2200	0.01	101	106
MZC150B10	–	150	2600	0.01	108	114
MZC160B10	–	160	3000	0.01	116	122
MZC170B10	–	170	3500	0.01	123	129
MZC180B10	–	180	4000	0.01	130	137
MZC190B10	–	190	4600	0.01	137	144
MZC200B10	–	200	5200	0.01	144	152

ZENER DIODES (continued)

FIGURE 1 – TYPICAL CAPACITANCE

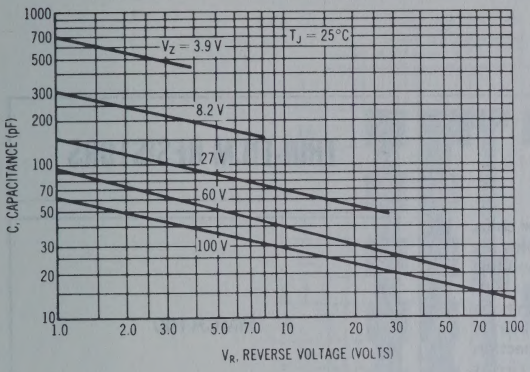


FIGURE 2 – TYPICAL FORWARD CHARACTERISTICS

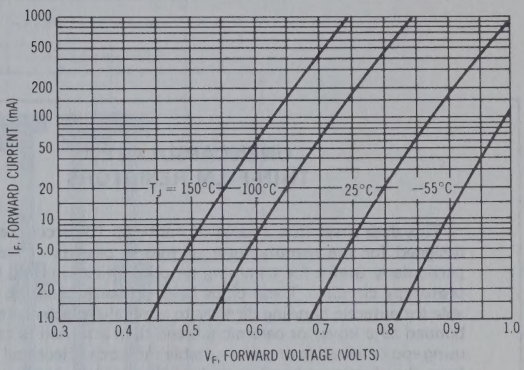


FIGURE 3 – TYPICAL NOISE DENSITY

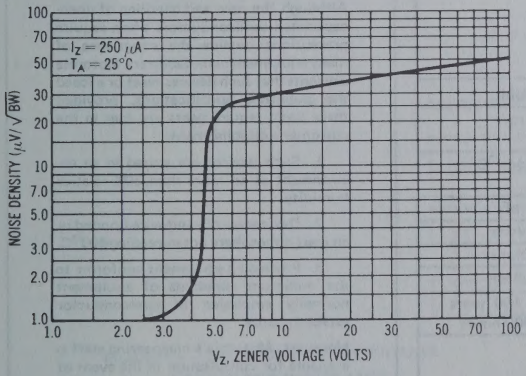
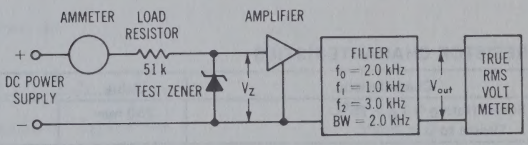


FIGURE 4 – NOISE DENSITY MEASUREMENT METHOD



NOISE DENSITY (VOLTS PER SQUARE ROOT BANDWIDTH) = $\frac{V_{out}}{\text{OVERALL GAIN } \sqrt{BW}}$

WHERE: BW = FILTER BANDWIDTH (Hz)
V_{out} = OUTPUT NOISE (VOLTS RMS)

The input voltage and load resistance are high so that the zener diode is driven from a constant current source. The noise of the amplifier is low so that it is negligible compared to that of the test zener. The filter bandpass is known so that the noise density can be calculated from the formula shown.

UNENCAPSULATED THIN-FILM RESISTORS

This data sheet lists a series of multi-tap 10-percent resistor chips designed for the manufacturer of hybrid circuits. These chips are particularly useful for trimming production circuits and for building prototype circuits. These chips have gold-alloy backing that is suitable for eutectic bonding directly to a metalized substrate; or may be bonded to a kovar or ceramic tab and then attached to the substrate using epoxy adhesive or other suitable methods. Electrical connection from the aluminum bonding pads of the resistor chip to other circuit elements is accomplished using conventional wire bonding techniques.

THIN-FILM RESISTORS

MMCR100

RESISTOR CHARACTERISTICS

Characteristic	Value	Unit
Power Rating @ T_A = 25°C Derate to 0 at 200°C	250 max	mW
Temperature Coefficient Resistance See Figure 1	-30 to +300	ppm/°C
Shunt Capacitance to Substrate	1.0 max	pF
Breakdown Voltage to Substrate	400 min	Volts
Resistance to Substrate	10^{15} min	Ohms
Voltage Coefficient	0.001 max	%/Volt
Drift @ 50% rated Power and 125°C	0.05 max 0.01 max	%/first 100 hours %/1000 hours

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in an inert atmosphere not exceeding 400°C.

3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

TYPE DESIGNATION

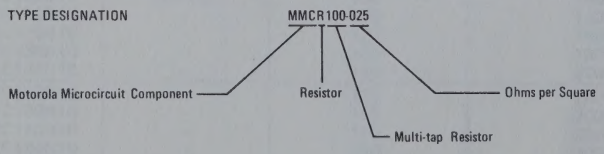


TABLE 1 RESISTANCE VALUES

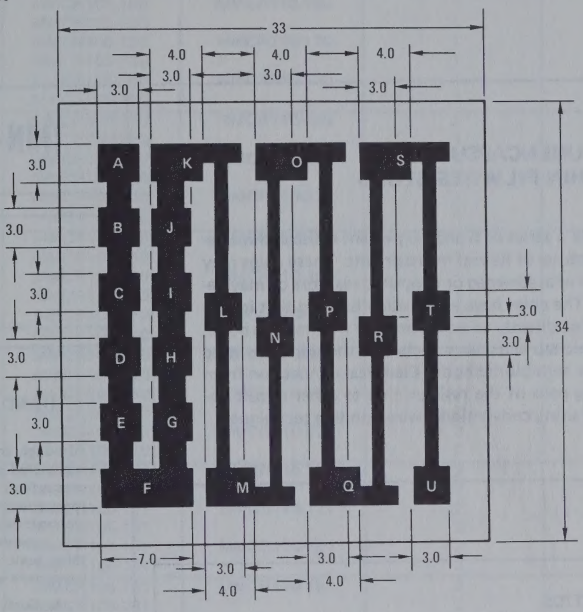
PART NUMBER	OHMS/□	END-TO-END RESISTANCE
MMCR100-025	25	2,750 Ohms
MMCR100-050	50	5,500 Ohms
MMCR100-100	100	11,000 Ohms
MMCR100-200	200	22,000 Ohms
MMCR100-300	300	33,000 Ohms

Each resistor chip is divided into 10 sections of 1 square, and 10 sections of 10 squares.

CONSTRUCTION DETAILS

SUBSTRATE – N-TYPE SILICON – 3 to 8 MILS THICK
ISOLATION LAYER – 10,000 Å SILICON DIOXIDE
CONTACT METALIZATION – ALUMINUM
BACKING – GOLD-ALLOY
RESISTOR ELEMENTS – NICKLE-CHROMIUM ALLOY

All dimensions are in mils



CHIP GEOMETRY

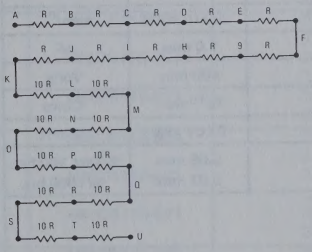


FIGURE 2 – EQUIVALENT CIRCUIT OF THIN-FILM RESISTOR CHIP

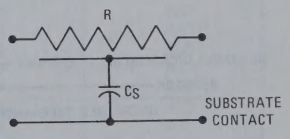
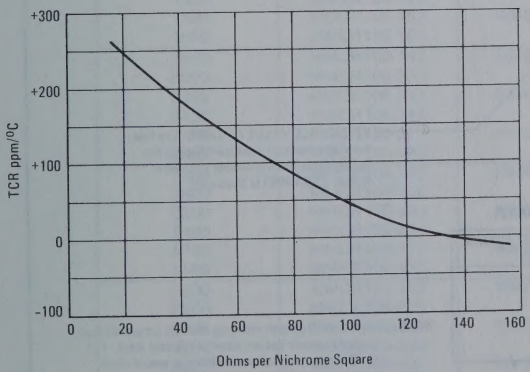


FIGURE 1 – NICHROME TEMPERATURE COEFFICIENT RESISTANCE



UNENCAPSULATED THIN-FILM RESISTORS

This data sheet lists a series of 5 and 10 percent resistor chips designed for the manufacturer of hybrid microcircuits. These chips may be used in conjunction with screened or deposited resistors or may replace them entirely. The chips have a gold-alloy backing that is suitable for eutectic bonding directly to a substrate; or they may be bonded to a kovar or ceramic tab and then attached to the substrate using epoxy adhesive or other suitable methods. Electrical connection from the aluminum bonding pads of the resistor chip to other circuit elements is accomplished using conventional wire bonding techniques.

THIN-FILM RESISTORS

MMCR105
MMCR110

HANDLING PRECAUTIONS

Although the care and handling of unencapsulated semiconductors often require precautions outside the experience of many equipment manufacturers, Motorola warrants that such devices meet or exceed the published specifications, provided three basic requirements are met in the customer's establishment.

1. Such devices are stored in an environment of no more than 30% relative humidity.

2. Devices are die-and-wire bonded in an inert atmosphere not exceeding 400°C.

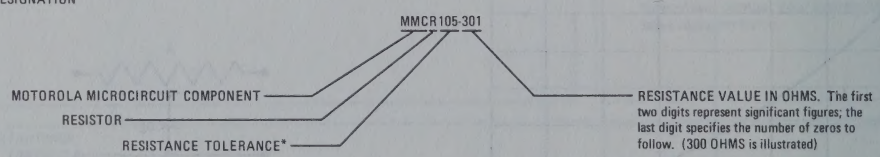
3. Processing equipment conforms to the minimum standards of equipment normally employed in semiconductor establishments.

Moreover, Motorola's engineering staff is available for consultation in the event of correlation or processing problems encountered in the use of Motorola semiconductor chips. For assistance of this nature, please contact your nearest Motorola sales representative.

RESISTOR CHARACTERISTICS

Characteristic	Value	Unit
Power Rating @ T_A = 25°C Derates to 0 at 200°C	250 max	mW
Temperature Coefficient Resistance (See Figure 1)	-30 to +300	ppm/°C
Shunt Capacitance to Substrate	1.0 max	pF
Breakdown Voltage to Substrate	400 min	Volts
Resistance to Substrate	10^{15} min	Ohms
Voltage Coefficient	0.001 max	%/Volt
Drift @ 50% rated power and 125°C	0.05 max 0.01 max	%/first 100 hrs. %/1000 hrs.

TYPE DESIGNATION


MMCR105-301
MOTOROLA MICROCIRCUIT COMPONENT
RESISTOR
RESISTANCE TOLERANCE*
RESISTANCE VALUE IN OHMS. The first two digits represent significant figures; the last digit specifies the number of zeros to follow. (300 OHMS is illustrated)

*RESISTANCE TOLERANCE

SYMBOL	RESISTANCE TOLERANCE PERCENT
101	1
102	2
105	5
110	10
120	20

NOTE: Only 5 and 10 percent tolerance resistors are available as standard products and are listed in this data sheet. 1, 2 and 20 percent resistors are available on special order.

TABLE I – RESISTANCE VALUES

Nominal Resistance In Ohms	Part Number 5% Resistors	Part Number 10% Resistors	Geometry Figure	Pad Terminations (Note 1)
10	MMCR105-100	MMCR110-100	1	A-B
11	MMCR105-110		1	A-B
12	MMCR105-120	MMCR110-120	1	A-B
13	MMCR105-130		1	A-B
15	MMCR105-150	MMCR110-150	1	C-D
16	MMCR105-160		1	C-D
18	MMCR105-180	MMCR110-180	1	C-D
20	MMCR105-200		1	C-D
22	MMCR105-220	MMCR110-220	1	C-D
24	MMCR105-240		1	C-D
27	MMCR105-270	MMCR110-270	1	B-D
30	MMCR105-300		1	A-D
33	MMCR105-330	MMCR110-330	1	A-D
36	MMCR105-360		1	A-D
39	MMCR105-390	MMCR110-390	1	A-D
43	MMCR105-430		1	A-D
47	MMCR105-470	MMCR110-470	1	A-D
51	MMCR105-510		1	A-D
56	MMCR105-560	MMCR110-560	2	C-D
62	MMCR105-620		2	C-D
68	MMCR105-680	MMCR110-680	2	C-D
75	MMCR105-750		2	C-D
82	MMCR105-820	MMCR110-820	2	B-D
91	MMCR105-910		2	B-D
100	MMCR105-101	MMCR110-101	2	B-D
110	MMCR105-111		2	B-D
120	MMCR105-121	MMCR110-121	2	A-D
130	MMCR105-131		2	A-D
150	MMCR105-151	MMCR110-151	2	B-D
160	MMCR105-161		2	A-D
180	MMCR105-181	MMCR110-181	2	A-D
200	MMCR105-201		2	A-D
220	MMCR105-221	MMCR110-221	2	A-D
240	MMCR105-241		2	A-D
270	MMCR105-271	MMCR110-271	2	A-D
300	MMCR105-301		2	A-D
330	MMCR105-331	MMCR110-331	3	A-B
360	MMCR105-361		3	A-B
390	MMCR105-391	MMCR110-391	3	A-B
430	MMCR105-431		3	A-B
470	MMCR105-471	MMCR110-471	3	A-B
510	MMCR105-511		3	A-B
560	MMCR105-561	MMCR110-561	3	A-B
620	MMCR105-621		3	C-D
680	MMCR105-681	MMCR110-681	3	C-D
750	MMCR105-751		3	A-B
820	MMCR105-821	MMCR110-821	3	C-D
910	MMCR105-911		3	C-D
1000	MMCR105-102	MMCR110-102	3	C-D
1100	MMCR105-112		3	C-D
1200	MMCR105-122	MMCR110-122	3	C-D
1300	MMCR105-132		3	C-D
1500	MMCR105-152	MMCR110-152	3	C-D
1600	MMCR105-162		3	A-D
1800	MMCR105-182	MMCR110-182	3	A-D
2000	MMCR105-202		3	A-D
2200	MMCR105-222	MMCR110-222	3	A-D
2400	MMCR105-242		4	A-D
2700	MMCR105-272	MMCR110-272	3	A-D
3000	MMCR105-302		4	A-D
3300	MMCR105-332	MMCR110-332	4	A-C
3600	MMCR105-362		4	A-C
3900	MMCR105-392	MMCR110-392	4	A-C
4300	MMCR105-432		4	A-C
4700	MMCR105-472	MMCR110-472	4	A-C
5100	MMCR105-512		4	A-C
5600	MMCR105-562	MMCR110-562	4	A-C
6200	MMCR105-622		4	A-C
6800	MMCR105-682	MMCR110-682	4	A-C
7500	MMCR105-752		4	A-C
8200	MMCR105-822	MMCR110-822	4	A-C
9100	MMCR105-912		4	A-C

TABLE I – RESISTANCE VALUES (continued)

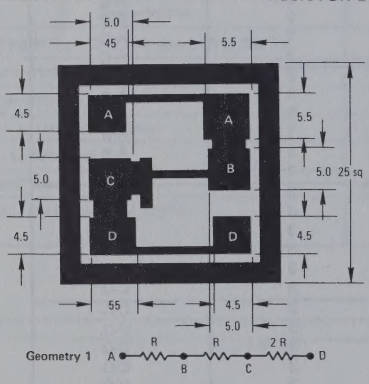
Nominal Resistance In Ohms	Part Number 5% Resistors	Part Number 10% Resistors	Geometry Figure	Pad Terminations (Note 1)
10,000	MMCR105-103	MMCR110-103	5	A-C
11,000	MMCR105-113		5	A-C
12,000	MMCR105-123	MMCR110-123	5	A-C
13,000	MMCR105-133		5	A-C
15,000	MMCR105-153	MMCR110-153	5	A-C
16,000	MMCR105-163		5	A-C
18,000	MMCR105-183	MMCR110-183	5	A-C
20,000	MMCR105-203		5	A-C
22,000	MMCR105-223	MMCR110-223	5	A-C
24,000	MMCR105-243		5	A-C
27,000	MMCR105-273	MMCR110-273	5	A-C
30,000	MMCR105-303		5	A-C
33,000	MMCR105-333	MMCR110-333	6	A-C
36,000	MMCR105-363		6	A-C
39,000	MMCR105-393	MMCR110-393	6	A-C
43,000	MMCR105-433		6	A-C
47,000	MMCR105-473	MMCR110-473	6	A-C
51,000	MMCR105-513		6	A-C
56,000	MMCR105-563	MMCR110-563	7	A-C
62,000	MMCR105-623		7	A-C
68,000	MMCR105-683	MMCR110-683	7	A-C
75,000	MMCR105-753		7	A-C
82,000	MMCR105-823	MMCR110-823	7	A-C
91,000	MMCR105-913		7	A-C
100,000	MMCR105-104	MMCR110-104	7	A-C

Note 1: The nominal resistance is measured between pad terminations as listed. Other resistances are available on the chip, with approximate values as shown in the schematic with the geometry, but these values are not tested or guaranteed.

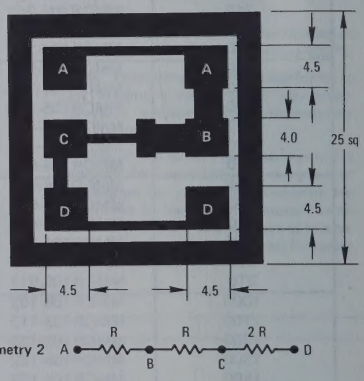
CONSTRUCTION DETAILS

SUBSTRATE – N-TYPE SILICON – 3 to 8 MILS THICK
ISOLATION LAYER – 10,000 A SILICON DIOXIDE
RESISTOR ELEMENT – NICKEL-CHROMIUM ALLOY
CONTACT METALIZATION – ALUMINUM
BACKING – GOLD-ALLOY

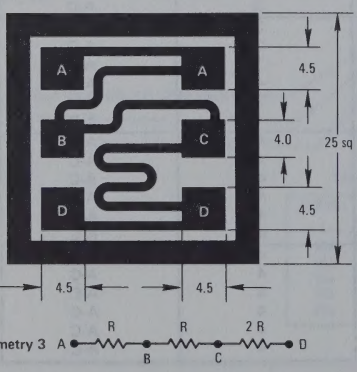
All Dimensions in mils



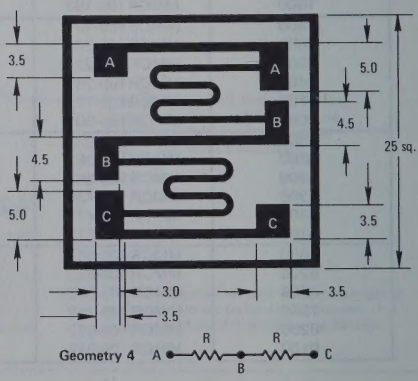
Geometry 1



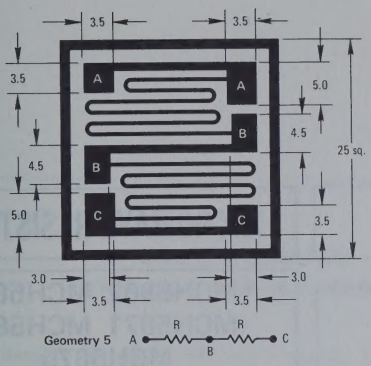
Geometry 2

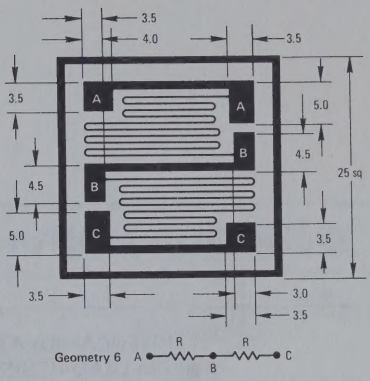


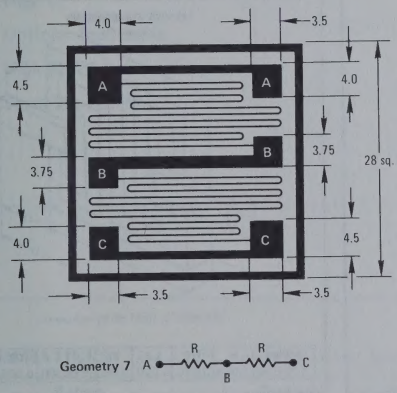
Geometry 3



Geometry 4







EQUIVALENT CIRCUIT OF THE THIN-FILM RESISTOR CHIP

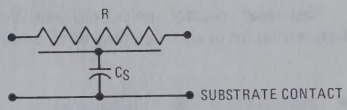
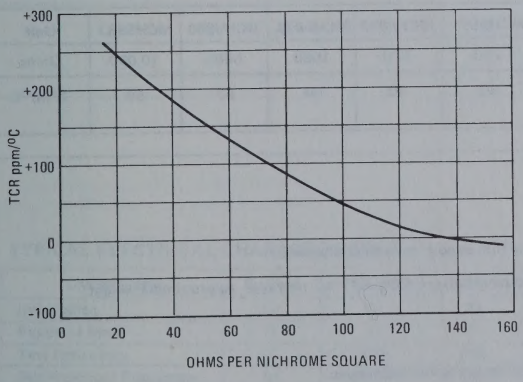


FIGURE 1 – NICHROME TEMPERATURE COEFFICIENT RESISTANCE



GEOMETRY	Number of Nichrome Squares
1	1
2	4
3	60
4	101
5	350
6	1132
7	1588

Advance Information

MICROWAVE RESISTORS

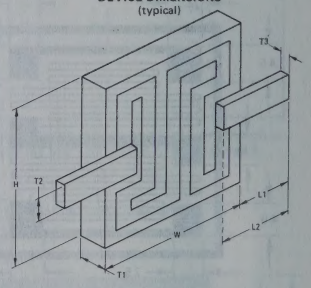
MCH5862 MCH5867
MCH5871 MCH5872
MCH5875
MCH5880 MCH5883

UNENCAPSULATED BEAM-LEAD RESISTORS

Beam-lead resistor chips designed for hybrid applications at frequencies up to and including microwave wavelengths.

- Small Die Size – 50 Mils Square typ
- Excellent Temperature Stability – 50 PPM typ
- Power Dissipation – 125 mW max
- Very Low Series Inductance

DEVICE DIMENSIONS
(typical)



(MCH5875-1500 ohms is shown)

Inches ±10 mils	H	L1	L2	W	T1	T2	T3
	0.050	0.010	0.020	0.050	0.00300	0.005	0.0003

TYPICAL ELECTRICAL CHARACTERISTICS (T_A = +25 C unless otherwise noted, ±10% tolerance)

Characteristics	Symbol	MCH5862	MCH5867	MCH5871	MCH5872	MCH5875	MCH5880	MCH5883	Unit
Nominal Resistance	R(nom)	5.0	50	250	500	1500	5000	10,000	Ohms
Temperature Coefficient	TC	50	50	50	50	50	50	50	PPM/°C

GENERAL INFORMATION and SPECIFICATIONS:

Fabrication and Material: Each device consists of a 400-Å-thick nichrome film deposit on a glass substrate.

Size and Weight: The die substrate size is 50 x 50 x 1.75 mils typ, beam dimensions are 5.0 x 20 x 0.3 mils typ. Approximate weight is 0.00013 gram each.

Handling: Restrict handling to a vacuum needle type operation.

Bonding: Restricted to lead-bonded accomplished by thermo-compression or ultrasonic techniques.

Packaging: Devices are packaged in 25-piece holders.

Minimum Order: Twenty-five units per type per single shipment.

THIN-FILM INDUCTORS

28 to 230 nH

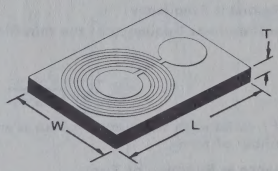
MCH5800 thru MCH5805

UNENCAPSULATED THIN-FILM CHIP INDUCTORS

. . . designed for use in UHF and microwave hybrid circuits for tuning and biasing applications.

- High Q
- Uniform Inductance
- High Self-Resonant Frequency
- Small Physical Size

DEVICE OUTLINE AND DIMENSIONS



	(Inches ±10 m)		
Type No.	L	W	T
MCH5800	0.190	0.190	0.010
MCH5801	0.192	0.192	0.010
MCH5802	0.220	0.220	0.010
MCH5803	0.225	0.225	0.010
MCH5804	0.233	0.233	0.010
MCH5805	0.240	0.240	0.010

MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Operating Current	$I_{C(max)}$	250	mA
Peak Device Temperature (relative to mounting)	T_{pk}	300	°C

TYPICAL ELECTRICAL CHARACTERISTICS (T_A = +25°C unless otherwise noted)

Characteristic	Symbol	MCH5800	MCH5801	MCH5802	MCH5803	MCH5804	MCH5805	Unit
Inductance	L_S	28	35	115	150	195	230	nH
Figure of Merit	Q	19	21	27	25	29	30	–
Test Frequency	f	200	200	200	100	100	100	MHz
Self-Resonant Frequency	f_R	1800	1700	1030	920	810	740	MHz
Series Resistance	R_S	1.8	2.1	5.5	4.0	4.5	5.0	ohms
Stray Capacitance	C_S	0.27	0.25	0.21	0.20	0.20	0.20	pF

APPLICATIONS INFORMATION

1. Equivalent Circuit of Thin-Film Inductor:
   Figure 1 is an equivalent circuit of the thin-film inductor.
   C_S – Distributed capacitance
   R_S – Resistance of inductor (function of frequency)
   L_S – Actual inductance (low-frequency)
2. Equivalent Series Circuit of Thin-Film Inductor:
   The presence of distributed capacitance affects the actual series resistance and inductance of the coil resulting in the equivalent series circuit shown in Figure 2.
   The equivalent inductance and resistance is related to the actual inductance and resistance according to the equations below:

$$L_{equiv} = \frac{L_S}{1-K^2}; \text{ where } K = \frac{f}{f_R},$$

f is the frequency of interest, and f_R is the frequency at which the coil inductance is resonant with distributed capacitance (C_S).

$$R_{equiv} = \frac{R_S}{(1-K^2)^2}$$

3. Self-Resonant Frequency:
   The self-resonant frequency of the thin-film inductor is:

$$f_R = \frac{1}{2\pi\sqrt{L_S C_S}}$$

C_S (pF) varies with the number of turns and is found to be $C_S = 0.15 + \frac{0.42}{N}$; where N is the number of turns.

4. Inductance as Function of Turns:
   A plot of inductance (actual) versus the number of turns is shown in Figure 3.
5. Spiral Inductor Figure of Merit, Q:
   The Q of a spiral inductor can be shown as:

$$Q = \frac{\omega L_{equiv}}{R_{equiv}}$$

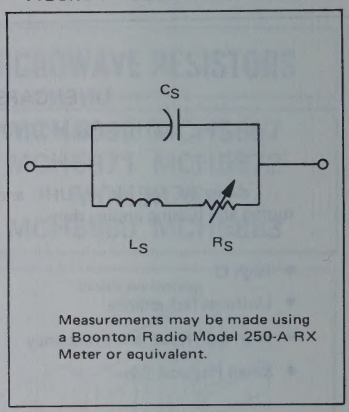
For design purposes at frequencies approximately $\frac{f_R}{8}$ or lower, C_S can be neglected, therefore Q can be written as $Q = \frac{\omega L_S}{R_S}$.

6. General Formulas Involving Q:
   (A) $R_P = R_{equiv}(1 + Q^2)$; where
   R_P = equivalent parallel resistance
   (B) $L_P = L_{equiv}\frac{1+Q^2}{Q^2}$; where L_P = equivalent parallel inductance
   (C) $Q = \frac{f_c}{f1 - f2}$; where f1 and f2 are half power points and f_c is center frequency.
   (D) $Q = \frac{R_P}{\omega L_P}$

NOTE: These miniature thin-film inductors are fabricated on a 0.010" thick alumina substrate using copper as the primary material. Motorola uses a unique photo-resist processing technique which makes possible conductor thicknesses not previously achievable in this small geometry.

We recommend that the devices be mounted using a nonconductive organic adhesive such as epoxy. Wire bonds can be made using parallel gap welding, soldering, ultrasonic, or thermo-compression bonding techniques.

FIGURE 1 – EQUIVALENT CIRCUIT



Measurements may be made using a Boonton Radio Model 250-A RX Meter or equivalent.

FIGURE 2 – EQUIVALENT SERIES CIRCUIT

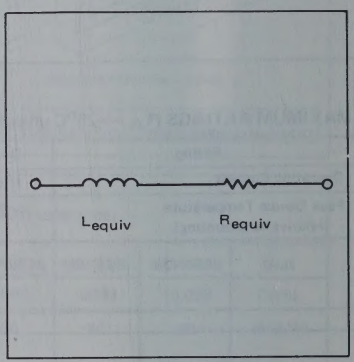
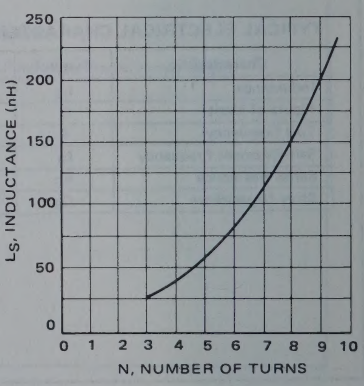


FIGURE 3 – TYPICAL ACTUAL INDUCTANCE per NUMBER of TURNS



BEAM-LEAD
MICROWAVE CAPACITORS

MICROCIRCUIT COMPONENTS

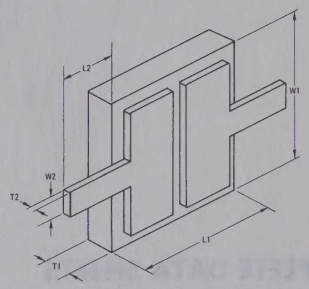
Advance Information

MICROWAVE CAPACITORS
1.8 to 57 pF

MCH5900 SERIES

UNENCAPSULATED THIN-FILM BEAM-LEAD CAPACITORS

. . . designed for use in UHF and microwave hybrid circuits as coupling or blocking capacitors. The gold beam-leads can be thermocompression bonded directly across small gaps in microcircuit lines. The beam-lead capacitors are of MOS construction with gold metalization and silicon-dioxide dielectric grown by a thermal diffusion process on a silicon substrate (possessing a low resistivity constant).



MAXIMUM RATINGS (T_A = +25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Breakdown Voltage	V_{bd}	100	Volts
Operating Temperature Range	T_A	-55 to +150	°C

DIMENSIONS (mils typ ± 10%)

DEVICE	L_1	L_2	W_1	W_2	T_1	T_2
MCH5901	26	10	26	5	3	0.3
MCH5902	26	10	26	5	3	0.3
MCH5903	26	10	26	5	3	0.3
MCH5904	26	10	26	5	3	0.3
MCH5905	26	10	26	5	3	0.3
MCH5907	42	8	42	6	3	0.3
MCH5908	42	8	42	6	3	0.3
MCH5909	42	8	42	6	3	0.3
MCH5910	42	8	42	6	3	0.3
MCH5911	42	8	42	6	3	0.3
MCH5912	42	8	42	6	3	0.3
MCH5914	84	16	84	12	3	0.3
MCH5915	84	16	84	12	3	0.3
MCH5916	84	16	84	12	3	0.3
MCH5917	84	16	84	12	3	0.3
MCH5918	84	16	84	12	3	0.3
MCH5919	84	16	84	12	3	0.3

TYPICAL ELECTRICAL CHARACTERISTICS (f = 1.0 MHz, T_A = +25°C unless otherwise noted)

Characteristics	MCH 5901	MCH 5902	MCH 5903	MCH 5904	MCH 5905	MCH 5907	MCH 5908	MCH 5909	MCH 5910	MCH 5911	MCH 5912	MCH 5914	MCH 5915	MCH 5916	MCH 5917	MCH 5918	MCH 5919	Unit
Capacitance (nom)*	1.8	2.5	3.2	4.0	4.8	6.6	8.0	9.6	11.2	13	15.6	23	27.5	33	40	48	57	pF
Temperature Coefficient**	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	PPM/°C

*Nominal Capacitance: MCH5901 ± 20%, other devices listed in the table have a tolerance of ± 10%. **Maximum

GENERAL INFORMATION and SPECIFICATIONS:

Weight: 0.00013 gram each.

Handling: Restrict handling to a vacuum needle type operation.

Packaging: Devices are packaged in twenty-five piece holders.

Minimum Order: Twenty-five units per type per single shipment.

INTRODUCTION

1N . . . INDEX
Numerical index of EIA-registered device types, with major electrical specifications

2N . . . & 3N . . . INDEX
Numerical index of EIA-registered device types, with major electrical specifications

DEVICE INDEX
Complete alpha-numeric index of all device types

COMPLETE DATA SHEETS
2N . . . & 3N . . . DEVICE SPECIFICATIONS

COMPLETE DATA SHEETS
IN-HOUSE NUMBERED DEVICE SPECIFICATIONS

MICROCIRCUIT COMPONENTS

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